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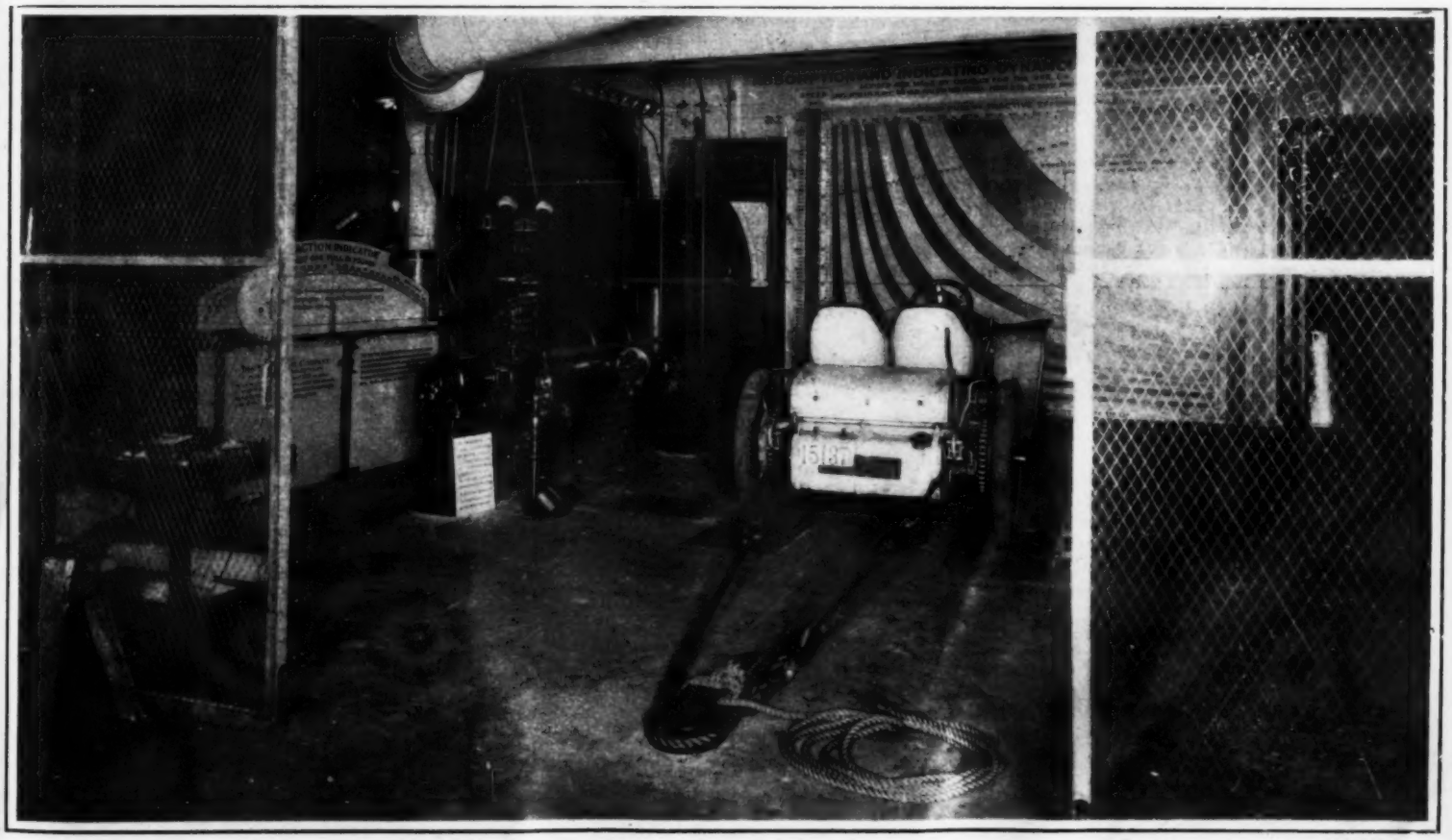
Indicating pointers. Dash pots. Pendulum. Hydraulic brake. Clutch. The paper friction pulleys upon which the driving wheels of the automobile rest. Clutch. Electric motor for driving power shaft in coasting tests.

THE POWER-ABSORPTION SHAFT SUSPENDED FROM THE CEILING OF THE FLOOR UPON WHICH THE PLANT IS LOCATED.



Traction indicator giving draw-bar pull in pounds. Electric motor driving speed-equalizing cone. Grade meter. Chart of horse-power curves.

TESTING WM. K. VANDERBILT, JR.'S, 90-HORSE-POWER MERCEDES RACER. THIS PICTURE GIVES AN EXCELLENT IDEA OF THE ARRANGEMENT AND APPEARANCE OF THE INDICATING APPARATUS.

THE NEW DYNAMOMETER AND TESTING APPARATUS OF THE AUTOMOBILE CLUB OF AMERICA

TESTING THE HORSE-POWER OF AUTOMOBILES.

THE INGENIOUS DYNAMOMETER OF THE AUTOMOBILE CLUB OF AMERICA FOR ASCERTAINING THE POWER DELIVERED AT THE WHEELS.

AN important aid to the improvement of the automobile has recently been put in operation in the club house of the Automobile Club of America in New York city. This new dynamometer and its allied testing apparatus will determine instantly the speed in miles per hour and feet per second, the drawbar pull or tractive effort, the horse-power at the rims of the driving wheels, the grade-climbing ability, and the power of the brakes of any automobile which is placed upon it.

There is no other machine in the world which will do the work of this one; and probably no other institution could afford to construct and operate a similar machine. It is of great importance to owners and purchasers of cars, and it will be found of great benefit to manufacturers, because it will enable them to determine precisely what their cars can do, and will give them a standard to which they can refer with confidence.

The dynamometer, besides being the most complete apparatus ever built for testing automobiles, makes it unnecessary to get special permission to speed machines in making a running test. Besides this, it will eliminate all danger of road accidents during tests, and give the results more quickly and accurately than in any other way. It is of the greatest value to the intending purchaser of an automobile, and to the manufacturer who wishes to close a sale. The purchaser can now say to the manufacturer: "I want a car of such horse-power, such speed, such drawbar pull, and that will climb such a grade. If this machine is shown by the club dynamometer to be what I want, I will buy it."

The dynamometer, with the club scales for weighing cars, should provide conclusive answers to all automobile conundrums.

It is provided with an electric fan device for catching the exhaust from the running automobile, in order that the air in the room may be kept clear of smoke and obnoxious fumes.

The word "dynamometer" is usually applied to a simple apparatus, either a spring balance for weighing the drawbar pull required to draw a carriage or railroad car at a given speed, or a power-absorbing device for consuming the power given off by an engine under trial. There are also numerous other forms. To obtain results it is always necessary to make calculations from the readings observed. The apparatus at the club is a machine upon which an automobile of any kind may be placed and operated, and the result read at once in speed, pull, and horse-power. It is therefore not only a dynamometer in the usual sense, but a calculator of the readings obtained by a dynamometer.

The club dynamometer is a moving track upon which cars can be fully tried out while remaining stationary and under observation. In 1904 Dr. Schuyler Skaats Wheeler, first vice-president of the Automobile Club, was requested by the club to invent, design, and build a machine for determining accurately the performance of cars of all kinds. The present machine is, therefore, the result of several years' attention to this problem on the part of Dr. Wheeler.

It is an assemblage of power-absorbing and measuring instruments and a large power chart with automatically-operated pointers. It carries the problem of power measurement, integration, and automatic recording of the final results much farther than has hitherto been attempted. It absorbs and measures the power so that, at a glance, the speed, tractive effort, and horse-power can be clearly seen and read at each instant. The measurements show the power delivered at the ground by the wheels of the automobile. This includes every element in the operation of the automobile, and, therefore, shows the net power that is available for driving the car.

Instead of traveling along as on a road, the car is held stationary by cables upon the floor, with its driving wheels resting upon two large drums, which reach up through the floor and which the driving wheels of the car cause to revolve. The revolution of the drums is resisted by a huge pendulum hanging below the floor, and attached to the drum shaft, not rigidly, but through a device furnishing a degree of friction which can be varied. This friction device consists of an Alden absorption-dynamometer brake, an apparatus which consists of seven main parts as follows: One or more smooth disks of cast iron which are keyed to the driving shaft—in this instance the shaft at the right, which carries the two large paper friction wheels; a casing which revolves through a short arc and has bearings on the hubs of the disks; [illegible] of thin copper plates secured to the casing, and one face of each of which is close beside and parallel to one face of a disk, while the other face, in conjunction with the housing, forms a pressure chamber; an oiling system which makes it possible to keep the copper and cast-iron friction surfaces thoroughly lubricated; a water system by means of which water is circulated under pressure through the pressure chambers; automatic and hand-operated regulating valves for varying the quantity and pressure of the cooling water; and finally a means of balancing and indicating the torque developed. In the particular

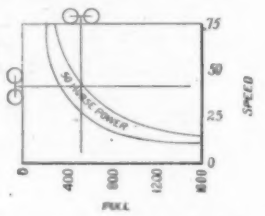


DIAGRAM OF HORSE-POWER CHART WHICH SHOWS AT A GLANCE THE POWER GIVEN OFF AT THE REAR WHEELS.

brake used in this instance, as it was found that the two disks were not needed when testing automobiles of low horse-power, a separate jaw-clutch was provided on the right-hand side of the dynamometer brake for the purpose of throwing one of the disks out of action. Instead of weighing the torque developed, as is generally done, this is used to move out from its vertical position a 560-pound pendulum, which can be increased by the addition of auxiliary weights to 1,600 pounds. The shaft which carries the pendulum has its right-hand end attached to the casing of the dynamometer brake, while to the left of the pendulum there are fitted two dashpots for the purpose of checking any fluctuations of the shaft, and, consequently, of the pointer which protrudes upward through the floor from its left-hand end and traverses a scale showing the drawbar pull or tractive effort. This scale is spread over an arc of 30 degrees and indicates up to 1,600 pounds in 10-pound divisions, and in both directions, i. e., whether the automobile is running forward or backward. As the torque developed is proportional to the deflection of the pendulum, the scale shows directly the drawbar pull, or tractive effort, of the automobile being tested. The correctness of the indicating apparatus was assured by hanging standard weights on the peripheries of the large drums. The main indicating pendulum has close beside it and parallel with it a smaller pendulum, which operates electric contacts that cause a motor-driven follower carriage to move in a horizontal direction across the large chart, and thus to shift the vertical rule to the position indicating the proper drawbar pull. Two carriages are provided, one for forward motion and one for the reverse, and when one car-

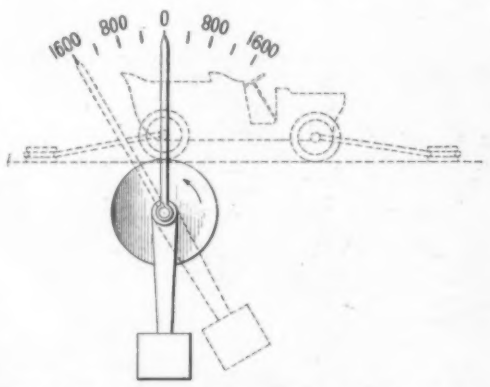


DIAGRAM SHOWING ARRANGEMENT OF PENDULUM AND INDICATING POINTER.

riage is in use the other is locked at the zero position.

The more difficult operation of measuring accurately the speed of the car, by moving a horizontal ruler vertically across the large chart, is accomplished by a special apparatus of some novelty. This apparatus performs its function without absorbing any of the power given off by the automobile under test, and also without affecting the accuracy of the tractive effort readings. The apparatus consists of a long cone revolved by a shunt-wound electric motor at a constant speed of 200 R.P.M., and having, for the purpose of verifying the speed, a bell that rings at each 100 revolutions, or at an interval of every 30 seconds. The cone is provided with a delicate centrifugal governor, which operates contacts causing a portion of the auxiliary shunt current of the driving motor to be by-passed through resistance when the speed drops or the auxiliary shunt circuit to be opened when the speed increases. By this arrangement the speed is kept constant within one-half of one per cent. A small wheel or disk in slight contact with the surface of the cone is mounted so that it can revolve freely upon a sleeve that is feathered to a splined shaft parallel with the face of the cone and driven by gears from the main drums. This sleeve has two contact points, between which plays back and forth an arm attached to the disk and having suitable points to engage them. Collector rings and brushes conduct the current which passes through these contacts. Unless the peripheral speed of the disk at the point at which it is in contact with the cone is such that it (the disk) is making the same number of revolutions as the sleeve and shaft which carry it, it will be retarded or advanced with relation to said sleeve sufficiently to cause the small arm which it carries to contact with one or the other of the contact points carried by the sleeve, the result being that the sleeve and disk are slid along (by means of a separate motor controlled by the contacts) on the shaft upon which they are mounted. By this movement of the disk along the cone, its speed is again varied until this becomes the same as that of the sleeve, whereupon the longitudinal movement of the latter ceases, and the horizontal ruler which is operated by cables connected with it comes to rest at the corresponding point on the chart. The method of speed measurement employed, based upon one element running at a constant speed that can be verified, insures great accuracy. The disk, when the car is running sixty miles per hour, must be drawn to a position near the large end of the cone, in order to run with the cone, while if the car is running only five miles per hour, the roller must be drawn to a position near the small end of the cone. The chart, which is of ample size to be read from a considerable distance, has 79 curves, plotted for showing the horse-power from 0.1 to 300 from the drawbar pull and the speed, in accordance with the formula

$$\text{H. P.} = \frac{\text{pull (pounds)} \times \text{speed (m.p.h.)}}{375}$$

On the board is painted the horse-power corresponding to each different speed and pull, so that the result at each moment can be seen by a glance at the crossing of the lines and without calculations.

The speed of the car may be read from the chart in feet per minute or in either of the popular ways of stating it, viz., miles or kilometers per hour and minutes per mile or per kilometer, by means of the several different scales provided.

All of the measuring apparatus is made reversible, so that when running backward the performance of the car may be measured.

As a secondary apparatus, a grade meter is provided. This is located at the left of the main chart, and operated by the pendulum indicator of the dynamometer. It consists of a pointer pivoted at one end, and having its other end arranged to travel over two parallel arcs graduated to show the degrees of the angle and the per cent (feet rise in 100) of the grade which the car is capable of ascending with the drawbar pull being developed at any moment. This latter factor is shown by a short pointer traveling over a vertical scale on the right-hand edge of the board, while a sliding clamp on the grade-indicating pointer is set in the first place at the figures on this pointer representing the weight of the car.

This grade meter is constructed to operate according to the following formulæ:

$$\text{Sine of angle of grade} = \frac{\text{tractive effort}}{\text{weight of car}}$$

$$\text{Grade in per cent} = \frac{100 \times \text{pull}}{[(\text{wt.})^2 - (\text{pull})^2]^{\frac{1}{2}}}$$

The maximum grade that can be ascended before slipping of the wheels occurs is one of about 35 per cent.

To observe an automobile coasting down hill, either forward or backward, it is necessary merely to start the electric motor on the shaft carrying the two large drums upon which the driving wheels of the automobile rest. The brakes may then be tested, and the wheels or gears or engine may be run free (not run

by the power of the automobile) and the relative friction loss in the transmission and wheel bearings of the automobile may be ascertained.

One of the first cars to be tested on the new dynamometer was a 90 horse-power Mercedes belonging to Mr. William K. Vanderbilt, Jr. Although the engine was apparently running up to speed, and developing somewhere near its rated horse-power, the horse-power given off at the rear wheels with the car running on the high speed at 74 miles an hour was but 30. Technical men are at a loss to explain this apparently tremendous loss of power in the transmission gear and chain drive, and it seems probable that a separate test of the engine will show that it does not develop anything like its full power at this speed of the car. On the low speed at 21 m.p.h., 50 horse-power was shown at the rear wheels, and a drawbar pull of 880 pounds was obtained.

In a test of a 30-horse-power machine, a maximum speed of 15 miles an hour was obtained on the first speed, with a drawbar pull of 510 pounds, and 30 horse-power was given off at the rims of the rear wheels. The ratio of pull to weight was 20 per cent, which was also the grade that could be climbed on this speed. On the second speed the car ran 25 miles an hour, with a drawbar pull of 340 pounds, and showed 22 horse-power at the wheels. On the third speed, which was a direct-drive, it ran 36 miles an hour, developed a pull of 270 pounds, and showed 25 horse-power at the rear wheels. This was a combined efficiency for the motor and transmission of 83.4 per cent, supposing the motor to develop the 30 horse-power at which it was rated. On the coasting test, in which the transmission and engine were revolved from the rear wheels, 38 horse-power was absorbed, or in other words, about a third more than the engine itself was supposed to develop. This shows the possibilities of the use of the engine as a brake in descending hills.

THE FARMAN AEROPLANE.

DESCRIPTION OF THE FLIGHTS MADE BY THIS RECORD-BREAKING MACHINE.

SINCE the winning of the Deutsch-Archdeacon prize of $10,000 by M. Henri Farman, on the 13th ultimo, at Paris, by his flight of one kilometer in a closed circuit with an aeroplane, so much attention has been drawn to this intrepid aviator and his machine, that we give herewith a *résumé* of most of the flights which he has made with it.

The first flight was made by Farman on September 30. This flight was in a straight line, and during it he covered a distance of from 30 to 80 meters (98½ to 262 feet), the machine apparently showing great stability.

From this time on he made flights very frequently, the striking points about these flights being that he landed each time without injuring the machine. Some of the latter flights leading up to the gaining of the Archdeacon prize for a flight of 150 meters are described herewith.

On the 15th of October, Farman started against a rather strong wind, and after traversing a few hundred feet, he rose in the air. He maneuvered the horizontal rudder, and as a result the wheels touched the ground for an instant, after which the machine immediately rose again and made a rather prolonged flight, during the course of which, by working his horizontal rudder, Farman was able to change the height of the machine and to describe a wavelike course in a vertical plane, which ended by another return to the ground and a subsequent final ascension that terminated only when the aeronaut received a signal from the Voisin brothers (the constructors of the machine), who were watching him. They noticed that the machine no longer remained on a level keel in the wind, and they feared that a gust from one side might upset it. The machine flew at a height of about 20 feet, and landed without sustaining any damage. As a rainstorm began, no further flights were made. The distance covered in the second part of the flight was 300 paces, and was approximately 285 meters (935 feet), but as there was no proper means of measurement, this excellent flight could not be officially recorded by the Aviation Commission of the Aero Club of France, and the official world's record for distance by a heavier-than-air machine was consequently still held by Santos-Dumont as the result of his 220-meter flight on November 12, 1906.

On the 19th of October, after four unsuccessful attempts, Farman, late in the afternoon, succeeded in flying more than 100 meters (328 feet). On October 23, he again flew a distance of about 170 meters (558 feet) at a maximum height of some 20 feet. The machine landed rather heavily, and a wheel was damaged; but the breakage was repaired the same evening by its constructors.

The next day the trials began at 3 P. M., and in one and a half hours five flights were made as follows: (1) After a short run along on the ground, the aeroplane flew 185 meters (606 feet) in 15 2/5 seconds at about 6½ feet height. The machine showed excellent stability, and Farman, by making this flight, gained a first prize of 200 francs and a bronze plaque for a flight of 150 meters. (2) A flight of about 150 meters (492 feet), which was not measured officially, and which was stopped by the spectators getting in the way. The time was 15 3/5 seconds. (3) 122 meters (400¼ feet) officially measured and timed in 11 seconds. (4) A flight which lasted 9 seconds, but was not measured, and during which the machine touched the ground twice. (5) Another flight which was not measured, and during which the machine touched the ground once. The first part lasted 8 seconds, and the second part 6 2/5 seconds. The speed of the machine was less than in the previous trial, as Farman caused it to fly at a sharper angle and to rise to a height of from 16 to 20 feet.

On the 25th of October, Farman made a number of excellent flights, among the principal of which were the following: 115 meters at 3 meters height; 85 meters at 4 meters height; 100 meters at 4 meters height, 115 meters at 3 meters height; 180 meters at 4 meters height, and 190 meters at from 4 to 5 meters height. The aeroplane met with no mishaps while in flight or while landing, and Farman seemed to be gaining in skill in handling it.

On the following day (October 26), after all but a few favored spectators had been kept off the parade ground, so that Farman now met with no interference, he made the best series of flights, and accomplished more than he had been able to do at any previous time. In the morning he made the following series of flights: 120 meters at 3 meters height; 85 meters at 4 meters height; 112 meters at 2 meters height; 155 meters at 2½ meters height; 180 meters at 4 to 5 meters height. Finally, at about 11 A. M., the machine was started at one side of the parade ground, and under the skillful guidance of Farman, it flew completely across the field at a height of about 3½ meters, the distance covered being immediately measured and found to be 363 meters (1,191 feet). Thus the record for flight in a straight line was officially broken. At 2 P. M. the record was again broken by the machine making 403 meters (1,322 feet).

As the aeroplane was doing so well, Farman convoked the members of the Aviation Committee of the Aero Club of France, who timed and measured the rest of the flights made that day. At 4 P. M., another flight of 350 meters at 3½ meters height was made in 27 seconds, which gave a speed of 13 meters per second, or about 28½ miles an hour. Finally, after starting from one corner of the parade ground and flying diagonally across it, Farman succeeded in making the longest flight of all—771 meters (2,529½ feet) at about 20 feet height. This flight was only terminated on account of the fortifications at the end of the field. It lasted 52 seconds, which corresponds to a speed of over 48½ feet per second, or about 32½ miles an hour. The total distance covered in the various flights on this day was 2,597 meters, or 1.6 miles.

After accomplishing these comparatively long flights in a straight line, Farman immediately began to practise making a flight in a circle. In his first attempt in this direction, on October 28, he made a quarter of a turn, and broke one of the wheels of the aeroplane in landing. At this time the aeroplane had been modified and enlarged somewhat. The double horizontal rudder had been changed to a single surface rudder located in front of the lower forward plane, a little higher up than before, while the upper plane of the rear pair had been modified in form, and made to carry more weight. Moreover, Farman had changed his method of starting. Formerly, he had allowed the machine to get up as much speed as possible while running on the ground on its wheels, and then, by a sudden twist of the horizontal rudder, the machine was made to rise quickly at an angle so sharp that it was with the greatest difficulty that he could move back the rudder and the planes to a sufficiently small angle of incidence to continue in horizontal flight; for when he attempted to do this, he would generally move the rudder too far, with the result that the machine would touch the ground, or else, if he did not direct the horizontal rudder downward again, the engine would stall, or the speed of the machine drop so low because of the increased resistance, that it would no longer be supported. Farman got over this difficulty by setting the forward planes at a sufficient angle for the machine to rise easily and gradually as it attained its maximum speed while running along on the ground. Thus it became unnecessary for him to use the horizontal rudder except when he was in flight and when he wished to change the height of the machine above the ground. As the rear steadying planes are practically horizontal when the machine is running along on the ground, if the operator should attempt to diminish the angle of the forward planes while in flight, this would cause the following planes to have a negative angle, which would no doubt upset the fore-and-aft equilibrium of the machine. Thus it can be seen that there is no chance of increasing the speed of the machine while in the air by diminishing the angle of the planes.

The months of November and December, 1907, were given up to attempts by Farman to fly in a circle, his object being to win the $10,000 Deutsch-Archdeacon prize, which was offered in 1904 for a flight of one kilometer in a closed circuit by any heavier-than-air machine. On November 7, he beat his 771-meter record by making a measured flight of 800 meters (2,624 2/3 feet). In an unmeasured flight which was probably 100 meters longer, he was in the air 1 minute and 10 seconds, and was able to describe a letter S. On November 9, after a number of preliminary flights, he made a circular flight estimated to be about 1,036 meters (0.64 mile) in length. The machine was in the air 1 minute and 14 seconds. He also made another flight in the form of a huge letter S. On November 11, Farman attempted several times to fly when there was a rather stronger wind than usual. He succeeded in rising and flying but a short distance, as the motor did not operate properly. On November 14, he flew successfully at first in a large semicircle. After making adjustments to the motor, he made several more flights, during one of which a propeller blade snapped off and was thrown down to the ground with great force. On November 18, Farman attempted to win the Deutsch-Archdeacon prize. He succeeded in flying a kilometer in a circle, but the machine touched the ground twice, just before and just after turning at the halfway point. The following day, Count de la Vaulx tried his new aeroplane and smashed it. Farman flew to his aid with his own machine, and reached the wrecked aeroplane before any of the automobiles were able to do so. On November 23, Farman for the third time attempted to compete for the prize. He made but one flight of from 120 to 150 meters, however, as a violent wind and rainstorm obliged him to house his machine. He flew once across the field, a distance of about 900 meters, and against a 12 to 18-mile wind. It was with considerable difficulty that he was able to make this flight without upsetting.

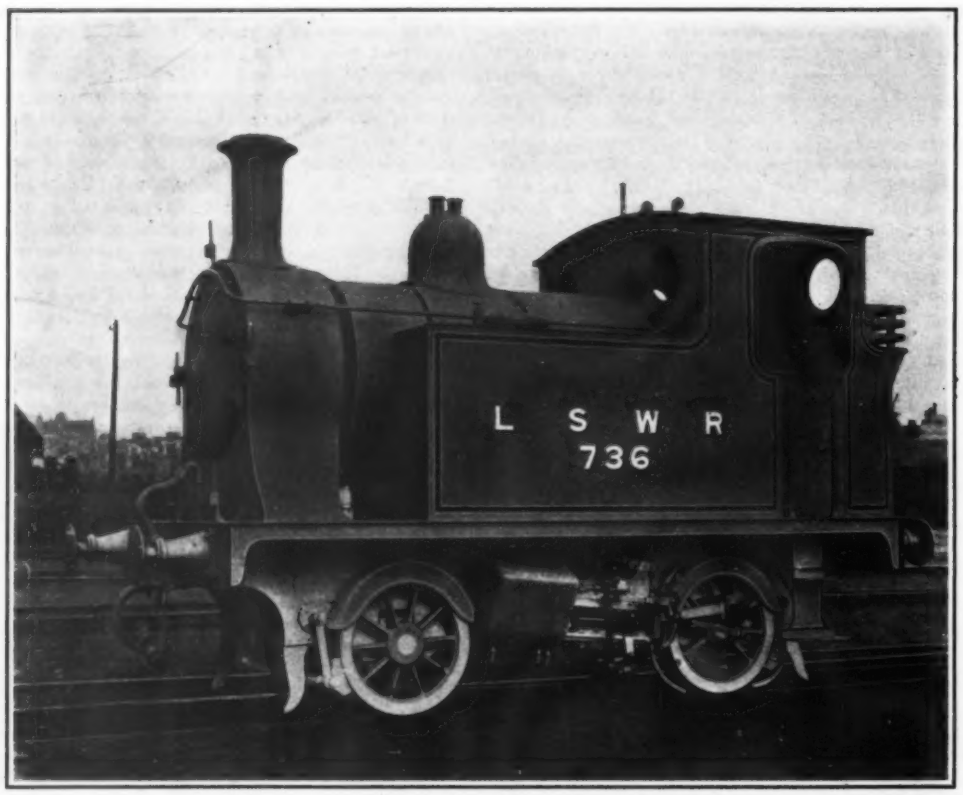
No flights of any account were made during December, as Farman was making changes upon his machine. On December 20, however, he made a number of short trials throughout the day, and toward dusk he flew 500 meters (1,640 feet). The rear steadying planes had been shortened considerably, and the machine as a result seemed to have a tendency to sway, although it was apparently able to make the turn with greater ease. A new carbureter and a magneto had been fitted to the motor. On December 21, the engine made 1,050 R. P. M., or 50 more than heretofore. This increased speed was due to warming the gas. The machine flew the whole length of the parade ground with ease. On December 20, Farman succeeded in making a kilometer in a closed circuit without touching the ground, but as the flight was not officially witnessed, he did not win the prize on this day.

On January 11, 1908, he twice again flew unofficially a kilometer in a closed circuit, but it was not until January 13 that he made the official flight and won the valuable cash prize. Two days later he experimented to ascertain how much dead weight the machine would lift. About 30 pounds was the largest amount of weight that he could successfully carry, so it was quite evident that the machine could not fly long distances, on account of its inability to carry sufficient fuel. Farman has since set about constructing another machine of a totally different type, having superposed wings set at a dihedral angle, and the aeronautical world is looking forward with interest to his further experiments with this other type of aeroplane, which should have a greater lifting power, and hence be capable of making long-distance flights.

AN INTERESTING LOCOMOTIVE

A NEW IDEA FOR SUBURBAN TRAFFIC.

THE latest development in motor-car practice for railroad operations, as shown in the accompanying illustration, is the outcome of the rapid growth in this class of traffic upon the London and Southwestern Railroad of England. The general practice in regard to the composition of such steam-motor coaches has been to attach one end of the coach pivotally to the frame of the engine, so that the whole forms one vehicle, the engine for this work being generally some small type that has been abandoned for ordinary traffic requirements. Such a combination, however, has many shortcomings, the greatest of which is in regard to the disconnection of the coach from the engine. To overcome these defects Mr. Drummond, the locomotive engineer to the above-named company, has designed a miniature locomotive for this work, though if necessary it can be used for other haulage operations within a limited scope. The engine measures only 19 feet 5 inches over buffers. There is a pair of single driving wheels and a pair of leading wheels, the adhesion obtained being sufficient without coupling. The wheels are 3 feet in diameter placed on an 8-foot wheel base. The outside cylinders have a bore of 10 inches by 14-inch stroke, the valve gear being of the Walschaert type. The boiler is of the water-tube type, having 99 tubes of 1¾ inches diameter, giving a total heating surface of 119 square feet; the smoke tubes are 216 in number and of 1½ inches diameter, 379 square feet, while the firebox has a heating surface of 73 square feet, the aggregate heating surface being 571 square feet. The grate area is 9.5 square feet; the working pressure of the boiler, 150 pounds per square inch. The water tanks have capacity for 500 gallons of water, while the fuel bunker supply is one ton. In total working order the locomotive weighs only 24 tons, and the tractive force on rails is 3,889 pounds. The engine is designed for the haulage of either one or two trailers. In the latter case facilities are provided for driving the train forward from the rear end, there being a compartment in the coach for this purpose. With this type of tractor it is possible to disconnect the engine from the coaches easily and quickly at any time, which is a decided advantage over the ordinary system of building steam-motor cars in England.



MINIATURE LOCOMOTIVE FITTED WITH WATER-TUBE BOILER AND WALSCHAERT GEAR FOR HAULING RAILROAD MOTOR COACHES.

A THOUSAND TONS A DAY.

THE records of the great Cunard Atlantic liners, the "Lusitania" and her so-called sister, the "Mauretania," are watched with augmented interest as time passes. First, we had the race with the German liners. They have been beaten. Now the competition is between the "Lusitania" and the "Mauretania." It is too soon to venture on an opinion. It is not too soon to say that facts, not opinions, so far, go to show that the "Mauretania" will be the faster ship of the two. They are both experiments, and that to a far greater extent than appears at first sight. The propulsion of an Atlantic liner by turbines is one novelty, the propulsion of an Atlantic liner by four screws is another novelty, and an ocean speed of 25 knots will, indeed, be a new thing under the sun.

While so much is uncertain, some things are, at least in a way, certain, and the data which follow will, we think, prove startling even to engineers accustomed to deal with large ocean ships. The "Lusitania" and her sister are alone in their dimensions, their power, and their speed. The scale on which they do things is colossal. It is true that precise figures, so far, have not been published, but enough is known to permit fairly accurate conclusions to be drawn.

It is not denied that the coal consumption is about 1,000 tons every twenty-four hours. It may be a little less or a little more. The bunkers hold 7,000 tons. How much remains in them at the end of each trip is only known by a select few. We take it for granted, however, that each ship burns 1,000 tons of coal every twenty-four hours—that is to say, the contents of the trucks of two 50-wagon coal trains, one train for the day and the other for the night. As there are twenty-five boilers, each boiler must take 20 tons per day, and the same every night.

It may be assumed that, the boilers being Howdenized and the coal good, each pound of coal will make 9 pounds of steam; that is to say, no less than 9,000 tons of steam are made every twenty-four hours, or, neglecting fractions, 375 tons of steam pass per hour through the engines. As the pressure is about 200 pounds absolute, each pound of steam will occupy about 2 cubic feet, which means that 1,680,000 cubic feet of steam pass through the engines every hour.

These are large quantities, but they shrink when compared with the flow of water through the condensers. That will be about 50 times the weight of the feed-water, or $50 \times 9{,}000 = 450{,}000$ tons per twenty-four hours, or 312 tons of water every minute, or 100,800,000 gallons per day. To realize what this means, it will suffice, perhaps, to say that the quantity would represent the water supply at 35 gallons per head per day of a city with nearly three million inhabitants, or almost enough for the city of Paris. It is a fortunate circumstance that there is plenty of water in the Atlantic Ocean.

Turning to the furnaces, we have equally astounding figures. Allowing 20 pounds of air per pound of coal, we have 20,000 tons of air passing through the grate bars every day. Taking the temperature of the supply at 100 deg., we have 14 cubic feet of air to the pound, so that 26,100,000 cubic feet of air enter the furnace every hour. A pipe 10 feet square would pa this quantity if the speed were that of a great gale 50 miles an hour.

We do not know with any certainty what the pow developed is. Taking it at 60,000 indicated hors power at 24 knots, we find that a thrust of 353 to would represent that power; but making the usu allowances, we may take it that the total net thru is probably somewhere about 180 tons, or, say, 6 tons for each propeller.

We have taken it for granted that the power dev oped on the shafts is 60,000 horses, but of this w have, as stated above, no certainty. The consumpti we have taken at 1,000 tons for all purposes. Th represents only 1.55 pound per effective horse-pow per hour. This means an exceptionally high economi efficiency, when we bear in mind that it stands f power delivered to the propeller shafts, and include all the auxiliaries. We not unnaturally ask ourselv whether the power is not less than 60,000, which woul account for the failure of the ship to maintain 2 knots; or whether the consumption of coal is n greater than the gigantic figure named? If, includin all auxiliaries, the consumption of fuel is really on 1.55 pound per net horse-power per hour, then th economic triumph of the turbine on the Atlantic i indeed remarkable.—The Engineer.

AN ELECTRO-CHEMICAL TIME RECORDER.

AN interesting use of voltmeters for measurin time was suggested by P. Spies at a recent meeting o the Congress of German Naturalists and Physicists.

In working with a voltmeter, times are generall read from the clock, in order to derive some conclusio as to the current intensity from the quantity of d composition products. The author suggests in th reverse manner measuring immediately the curren intensity, so that the voltmeter will give the duratio of current passage, and accordingly the duration o any process so controlled as to coincide with the pa sage of current through the apparatus.

Instead of measuring the small amounts of gas se arated in the ordinary oxygen-hydrogen voltmeter i the manner generally followed, the author determine these amounts by the volume of liquid displaced b the gases, using a narrow capillary tube about 1 to square millimeters in cross-section. This proce allows of a surprising accuracy, the apparatus demo strated by Mr. Spies possessing, with a current inte sity of 1.43 amperes, a sensitiveness of 0.003 secon per division. This sensitiveness is fully sufficient t demonstrate the free fall of bodies for heights of or even of 20 centimeters. The corresponding fallin distances, according to theory, would be 0.404 an 0.202 second respectively, while the 134.6 and 67 divisions, respectively, obtained in the apparatus ar far more readily demonstrated by projection with th device than in any other chronoscope so far known

Special advantages claimed for this curious appa ratus are the absence of any movable parts operate by engaging and disengaging, the ease of standardizing and the constancy of the value of each division in th several parts of the scale, this value being controlle at will by varying the current intensity, so as to adap it to the conditions of each case. In order to measur the speed of a projectile through a relatively shor distance, the current intensity would have to be chose greater, so as to give more divisions per division.

In a paper in Comptes Rendus, M. Jouguet appli the theory of similitude to the study of air resistanc If the velocity of the moving body A is feeble, it r sults from a theorem of Helmholtz that the air move sensibly as if it were incompressible, very viscous, an a very good conductor of heat. The resistance which i exerts to the motion of A ought therefore to be analo gous to that of water. It is doubtless due to the vi cosity of the fluid, and hence Poncelet and Saint-Ve nant's theory can be applied. The author has pre viously shown under what conditions the law of simil tude can be applied to this theory, and that it leads t a proportionality approaching the square of the v locity. This has been confirmed by experiment, notabl by Renard's researches. If the velocity of A is ver great, the theorem of Helmholtz shows that the a behaves like a feebly conducting, feebly viscous bu very compressible fluid. When the velocity of A i greater than that of sound, the resistance it exp riences is probably then due to the formation of compression wave which precedes it. From this th author deduces mathematically that at very grea velocities the resistance of the air is proportional t the square of the velocity.

ELEMENTS OF ELECTRICAL ENGINEERING.—X.

CONTROLLING DEVICES FOR RAILROAD MOTORS.

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY.

Continued from Supplement No. 1672, page 39.

AS EXPLAINED in the preceding chapter, such motors ordinarily have series wound field magnets. Still, attempts are constantly being made to derive some benefit from the energy developed when cars are descending grades; but the regenerative principle that would allow return of the energy to the line can be accomplished with shunt wound motors only. Combinations of the two methods of exciting the fields might be used, resulting in a sort of a compound motor, whereby the desirable features of the series winding may be utilized for traction, and those of the shunt for permitting the generator action during the coasting. On level tracks not much economy is offered by this double use of the motors—the only opportunity of returning energy to the system being during the stopping process. In hilly regions, however, the coasting may represent quite a proportion of the trip, and a saving of 30 per cent in the total energy may be possible. Series wound motors are quite incapable of becoming generators under these conditions, for they cannot generate until the field magnets are excited, and as soon as the circuit is completed, current flows from the line in the direction always to give the wrong polarity. Experiments are now being conducted with car equipments involving the regenerative principle, but have not yet demonstrated their worth or reliability. It is certain, however, that economy of operating expenses is the watchword of progressive power stations. This chapter will give a direct illustration of the abandonment of a good method of car control, for one that is still better, and the end is not yet. The explanation will be limited to past and present standard practice in American railways.

In starting a series motor, only enough electromotive force is needed to overcome the ohmic resistance, but for increasing the speed the pressure must be increased to overcome, in addition, the counter electromotive force generated in the motor. With a given load it has been found that the speed of a series motor varies directly with the voltage. For railway motors then, to have the qualification of variable speed, some means of procuring a variable electrical pressure must be sought. An arc lighting dynamo is a machine for supplying a constant current and any number of volts, and some original experiments with electric cars in Cleveland, Ohio, in 1886, were made using such dynamos for power. In order to allow the effective operation of the regulator on the machine, the different cars were connected in series; though this can be done for reasonable limits of potential, and for a few cars on a short line, the system becomes impossible for a large number. The constant potential system of delivering the energy to the different cars is the only

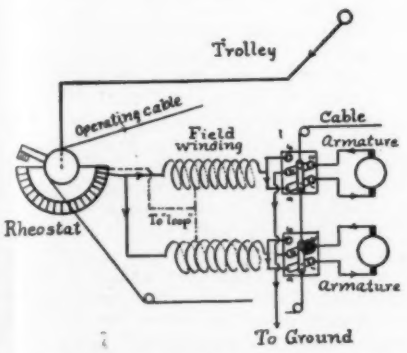


Fig. 37.—Diagram of Car-Wiring, Showing Two Series Motors Permanently Connected in Parallel, and Controlled by One Rheostat and Two Reversing Switches.

practicable one. Five hundred volts have been found to be a convenient pressure, and increased number of cars or increased loads merely mean more amperes. Of course large conductors are needed to transmit the thousands of amperes—a fact readily judged from the size of the "feeders" alongside an electric railway. But each car is independent of the rest, the insulation of line and motors is not difficult, and the generators at the stations work under conditions of economy and convenience.

With this system decided upon, there is still the unavoidable necessity of a gradual acceleration of speed of the motors—requiring first a small electromotive force, and increasing by steps, imperceptible to passen[illegible] maximum. How can this variable number of volts be obtained from the approximately constant 500?

The most obvious and crudest solution is to put a rheostat in the circuit of each car and have this constantly under the control of the motorman. By Ohm's

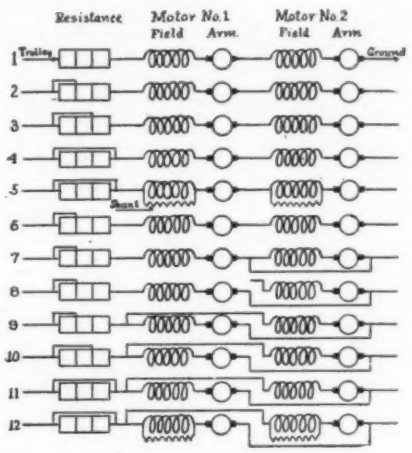


Fig. 38.—Combinations in an Ordinary Street-Car Motor "Series Parallel" Speed Controller.

law the number of volts required to drive a current through a resistance is obtained by multiplying the number of amperes and ohms together. Obviously, by making the rheostat large enough, any desired current may be carried, and any number of ohms inserted in the circuit. Thereby, out of the delivered 500 volts the rheostat would waste any required number, and the motors would get the rest. At start, all the resistance would be included, and the motors get the minimum voltage; at full speed all the resistance would be cut out, and the motors receive the full pressure. The energy thus wasted in the rheostat is degraded into mere heat, therefore fireproof constructions are to be sought, and those well exposed to radiation.

Sprague's installation in Richmond, Va., in 1887, may be said to be the first commercially successful electric road. In the motors for this and some subsequent lines, the builder sought to minimize the great loss in the controlling rheostats by letting the field magnet winding serve as the desired resistance. A number of separate sections were employed, some of them wound with German silver wire, and by a suitable "controller" these coils were all connected in series at the start, and then after various combinations, to produce uniform gradations, were finally connected in parallel to give full speed. (Although thus involving the use of the words "series" and "parallel," this controller does not represent the construction meant by the modern controller.) Sprague's attempt at economy was rather an expensive one; at least his application of it to congested city traffic was unfortunate, for the slow movement of cars often required the resistance to be kept in circuit unduly long, and the result was a constant burning out of field coils.

The Thomson-Houston system was successful from the first, for in it, reliability rather than economy of control was regarded as of first consideration. A noncombustible rheostat, made of iron, slate, and mica, quite apart from the motors, was used, and protected them from undue heat. Basic patents covering the use of the "magnetic" blow-out switch and the "underrunning" trolley wheel were of course of immense value in giving this system the lead which it soon gained.

Most cars are equipped with two motors, many of them with four. Taking the case of the former, just how should one motor be connected with reference to the other? Economy dictated that at start the two should be in series, and for full speed, in parallel, but experimental work, though conducted with great zeal and considerable expense, revealed the difficulties of accomplishing, in a manner satisfactory to passengers and to motors, the transition from one condition to the other. Either a violent jerk was given to the car, or a dangerous flash was produced at the brushes of one of the motors or at the switches. Pending the more satisfactory solution of this problem, the simple expedient was adopted of permanently connecting the motors in parallel, with one rheostat to control the current for both.

Whatever the method of control of a railroad motor both directions of rotation are always to be provided, hence reversing switches are needed. Direction of rotation of an electric motor is not affected by exchanging the extreme terminals, as in exchanging trolley and ground connections; the current must be reversed in either the armature or the field, but not in both. A single reversing switch was originally used in the two motors, but with low resistance armature windings, a variation in brush contact readily causes an unequal current to flow in the two paths, with consequent overloading of one motor. By use of two reversing switches, the field resistance is added to that of the armature for each motor, and the combined amount of resistance causes a more equal division.

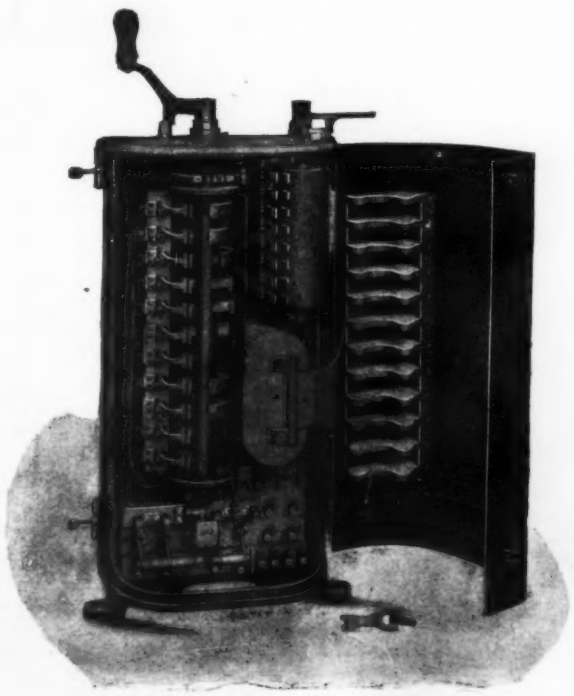


Fig. 39.—K-10 Series Parallel Controller.

Fig. 37 shows a simple diagram of the entire connections. Current may be considered as coming from

the trolley and passing to the pivot of the rheostat arm. As soon as contact is made with the resistance plates in the semi-circular trough, the path is on to the next but last contact, where the current divides itself between the two motors. After flowing through the entire winding of the field spools, the currents pass to the reversing switches. These consist of insulated brass levers hinged at points 1 and 2, and arranged to be kept parallel with each other, and make contact with either 3 and 4, or 4 and 5. Wire from field connects to both 3 and 5, while point 4 is attached to "ground," i. e., to frame of motor. Arrow heads show direction of current. The reader can imagine the switch to be moved to the other position, and he will then see that the arrows will be reversed in the armature circuits. About two and one-half turns of the rheostat handle moves the rheostat arm to its extreme position. When this position has been reached a new path has been provided, shown by dotted lines to "loops" left out in the field winding; by this path, about one-third of the winding is cut out, resulting in a weakened field and increased speed. The full field was available for starting, but a reduced strength for fast running.

To start the ordinary short cars equipped with two motors, 30 amperes per motor were often required, and therefore with the two in parallel, 60 amperes had to be drawn from the line. The rheostats normally had about 20 ohms resistance, therefore considerably more than half might be cut out before the motors would start. Of course the first part comprised the greater portion of the resistance, so the movement of the arm to accomplish this reduction was relatively small.

It is easy to see that if the motors were in series, the same 30 amperes that flowed through one motor would also flow through the other, and that the start could then be effected with only one half the expenditure of energy required for the multiple or parallel arrangement. Also for slow speeds in city streets, the series connection would be more economical than the other, for with the former, only 250 volts would be impressed upon each motor, resulting in half speed, while with the latter the same could be accomplished only by wasting 250 volts in the rheostat and letting the motors receive the other 250. The economy of operation at full speed would not depend on the particular means of reaching it, but electric power was first applied to traffic in the most congested parts of the cities, and the need of reasonable economy in frequent starts and slow speeds made the demand for a "series-parallel" controller one that engineers at length were able to fulfill. The urgency of the case was greater in consequence of the overloaded condition of the power houses. Means of making large generators had not been found, the small existing ones were quite inadequate to meet the demands for heating as well as running the cars, and the reliable device that promised economy of the current met with quick reception.

The difficulties that previous experimenters had encountered in making the proper change from series to parallel arrangement of motors were overcome in a surprisingly simple and effective manner by Mr. W. B. Potter, about 1891; he was then an assistant in the railway engineering department of the Thomson-Houston Electric Company at Lynn, but is now the head of the department for that work with the General Electric Company at Schenectady. In substance, his method was momentarily to short circuit one of the motors, thereby transferring the entire load to the other, then to disconnect the former and reconnect it to the circuit, but now in parallel rather than in series with the latter. In order to reduce the shock to car and active motor, and to provide a more uniform gradation of speeds, a resistance that had been in circuit at the start was reinserted just before this critical transition was made. Even with the two motors in series, their resistance was still too small to admit starting without the addition of some external resistance, but experiment showed that this need not be more than 6 or 6½ ohms, instead of the 20 ohms formerly used.

To fit the great variety of railway traffic, a surprisingly large assortment of motors have been made with still greater diversity in the particular apportionment of the different combinations that may be found in the "controllers." A typical one may, however, be illustrated, the one mostly used for ordinary street cars. Diagrammatic illustrations of the successive circuits, as afforded by a progressive movement of the handle, are given in Fig. 38. In it a commutator is represented by a circle, with two radial brushes in contact, and a field winding by the coiled lines. Reversing switches are omitted. Twelve steps may be traced as follows:

1. Motors in series, with all the resistance.
2. Motors in series, with two-thirds of resistance.
3. Motors in series, with one-third of resistance.
4. Motors in series, with no resistance.
5. Motors in series, with shunted field winding.
6. A return to Combination No. 2.
7. One motor short-circuited.
8. One end of this motor open-circuited.
9. This end brought into *parallel* connection with other motor—two-thirds of the resistance still included.
10. Motors in parallel with one-third of resistance.
11. Motors in parallel with no resistance.
12. Motors in parallel with shunted field winding.

It will be seen that in positions 1, 2, and 3 of the series connection, and 9 and 10 of the parallel, the resistance is included in the circuit, and these are denoted as starting points. Positions 7, 8, and 9 are the transitional ones, readily detected on the top of a controller by their absence—a considerable blank space suggesting the location; as here one motor only is doing all the work, the contact cylinder must not be allowed to stop on any of these points; 4 and 5, 11 and 12 are the economical running positions, the former corresponding to about one-half the speeds of the latter. In cities abounding in hills or grades, positions 5 and 12 are often omitted. Motormen are found prone to try to climb hills with the weakened field magnets, thereby demanding abnormal and ruinous currents in the armatures, when in reality these positions are intended for light loads, level tracks and infrequent stops.

Failure attended the first attempts to use these controllers from four causes. First, a single controller for a car was deemed sufficient, and as it was located beneath the floor, like the original rheostats, accessibility to examine or repair the numerous contacts was not given. Second, no indication was given to the operator as to the exact position of the contacts, resulting in disastrous arcs and melting of metal. Third, no means of suppressing the ordinary and inevitable arcs was provided. Fourth, no interlocking devices were applied to prevent damage due to ignorance or carelessness. These were successfully avoided, respectively, by using two identical controllers, one on each platform; by using a notched wheel and roller that would allow definite positions only; by equipping the entire row of contacts with a magnetic "blow-out"; by locking the reversing switch, so it could not be turned while the current was on, and by providing additional switches for cutting one motor entirely out of circuit in case of accident to it, and preventing the controller handle from then being turned further than corresponded to the series position.

A view of the inside of such a series-parallel controller is given in Fig. 39. The movable contacts are mounted on a vertical cylinder, occupying the central position, and successively touch the stationary "fingers" in a vertical row at the left. In the upper right hand corner are seen the reversing switches—for convenience also mounted on a cylinder. Just below is the coil of copper ribbon that is in series with the main line, and used to energize the "blow-out" magnet. The entire back of the case forms one pole, while the other is a slab of cast iron long enough to reach the entire length of the main cylinder; in the cut it is shown hinged back to allow access to the contacts; on its inner face are mounted insulating partitions resembling shelves; these shut in between the contacts and so lengthen the path from one to the next as to diminish the likelihood of the formation of destructive arcs. At the bottom are the two cut-out switches, one for each motor. The oblong hole in base is for entrance of the flexible cables that make connection with the motors.

With light cars equipped with single motors, it may be possible still to find some of the old simple rheostats, but more than ten years' experience has demonstrated the highly satisfactory performance of the "controllers." Even in cases where single motors are now installed, the controller is still provided, for though in such cases additional resistances must be inserted, and no economy of operation over the ordinary rheostat is offered, provision is made, by a few simple changes, for the addition of the second motor with the full series-parallel advantages.

Occasionally, the insulation on the blow-out magnet breaks down, and the coil becomes short-circuited, then arcs, resembling those seen when a trolley wheel jumps the wire, come from inside the controller case, and cries of "fire" and wild panic result. All that needs be done in such an event is for some cool-headed person to pull down the trolley pole.

An interesting extension of the principle of controlling railroad motors, is given in the handling of entire trains. In order to maintain schedule time and preserve definite headway, uniform acceleration and braking must be provided, independent of the number of cars constituting one train. This condition can be met by the sole means of having every car equipped with motors, yet controlled from any one car by a single operator. The solution was first made by that eminent engineer, Lieut. Sprague, and adopted on the Chicago and Boston elevated roads. In essence, the system consists in providing every car with the equipment necessary to allow it to be operated singly, then to couple any number in a train. The series-parallel controller on each car is not operated directly, but through the medium of a "master" controller. Electric couplings containing the requisite number of wires, make identical connections between all the cars, and when the master-controller is turned, the series-parallel controller on that car is at once operated, and also, in exact synchronism, the controllers on all the other cars turn on the current for their motors. The motorman does not even determine the rate of acceleration of the motors. He turns the handle at once to the full speed position, but the operating cylinder of the master-controller responds only as fast as air can escape from a checking cylinder, and the valve for the egress of the air is in turn controlled by a relay magnet in the main line; only when the current is below a certain minimum can the further rotation of the master cylinder take place. Removal of the hand from the knob at the top of the handle at once and automatically shuts off the power from the whole train. Ordinary automatic air brakes, such as are found on steam trains, are used for stopping.

Severe and crucial tests have been made on the effectiveness of this "multiple-unit" method of control, as it is called. Trains have been made up, but without the use of the mechanical couplings. All gradations of speed, with such trying conditions as grades, curves and sudden stops were tried, yet no bumping or separation of cars ordinarily resulted. Indeed, in the ordinary operation of the trains around some of the sharp curves in the Boston subway, the mechanical couplings sometimes unhitch, but the motorman may be ignorant of the accident—to him the train is still a unit.

The case of electric locomotives has brought out its own difficulties. If still operating at about 500 volts the current required is very large—perhaps 2,000 to 3,000 amperes. How best to get the current to the locomotive is a matter not yet satisfactorily settled, but with that provisionally cared for, the construction of the controllers has received special attention. The large contacts and considerable pressure needed to make good electrical connections involve much mechanical friction. Sometimes a large hand wheel is provided for moving the contact-cylinders, and as much muscle may be needed as to steer a ship. With such large currents, the ordinary series-parallel combinations result in too much burning of contacts and jerky motion of the motors, and a larger number of resistance steps are provided, with the further expedient, that after the motors have reached the half-speed condition, in series, the current is entirely shut off for a moment, the parallel connections made, and with a suitable cutting out of resistance full speed then attained.

In the locomotives recently built for the New York Central and New Haven Railroads, the multiple-unit method of control has been adopted. This means great relief to the motorman, or engineer, as he may continue to be called, and also allows two or more locomotives to be coupled together and yet operated by one man.

Four-motor equipments are common to long cars. In such cases the motors on one truck are permanently connected in parallel, and then the one pair is put in series or parallel with the other pair by the operation of an ordinary controller, though perhaps fitted with extra heavy contacts. The same cars could be used for slow interurban use, with the four motors in series, or for very rapid suburban transit by allowing the controller finally to put the four motors in parallel. Such extreme variations of speed are not often desired nor entrusted to the ordinary motorman.

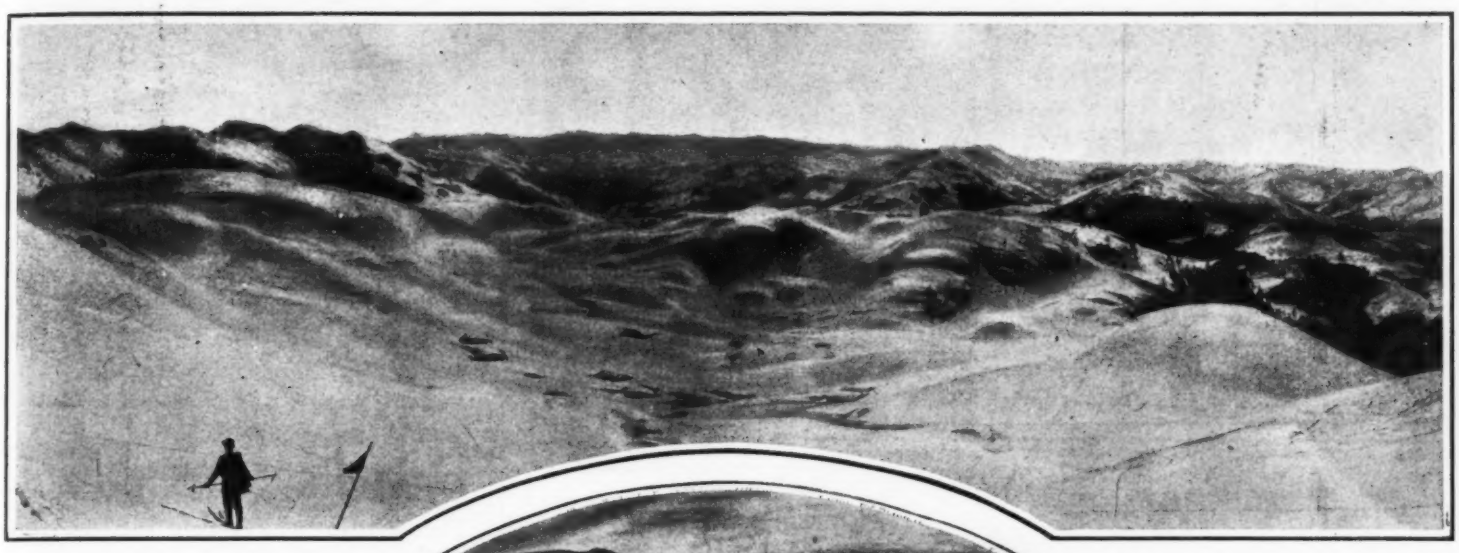
It is an old idea to turn the series motors into generators to assist in stopping the cars. Of course, the direction of rotation is always wrong to allow this to take place, so a special reversing switch is needed to make the proper equivalent change in the electric connections. The current, too, must be controlled by being led through a variable resistance. The principal defects in the proposal consist in the fact that a series machine does not always generate until the external resistance is quite small, and when the generation once begins, altogether too much current is apt to flow. The sudden "taking-hold" of the current makes a car almost stand on end. Sometimes, too, the presence of oil or dirt on the commutators, or insufficient residual magnetism, might prevent the machines from generating at all; and further, on a grade, the car could not stop, but must maintain enough speed to keep up a certain generating action. The regular mechanical brakes are needed as reliable accessories, and in nearly every case the electrically operated brakes have proved precarious and even dangerous.

The eleventh article will consider the means of distributing electrical energy from central stations, by means of direct currents.

Removal of Oil Paint.—When the use of strong lye for the removal of paint and varnish does not suffice, take, according to Werkstatt, a mixture of 2 parts of spirit of sal ammoniac and 1 part oil of turpentine. This mixture must be well shaken before use. After it has been allowed to work for a few minutes on the paint, the latter can be rubbed off with excelsior.

FAUNA AND FLORA IN WINTER.*

THE CHANGES WROUGHT BY COLD.



THERE IS WONDERFUL DETAIL OF LIGHT AND SHADOW OVER BROAD EXPANSE OF SNOW.

THE BEAUTY OF THE EARLY SUNLIGHT.

In countries where the winters are accompanied by snow and frost, the inhabitants see sudden transformations in nature's form and color, such as is not granted to the people of warmer or more equable climates. To awake some morning and find the whole world out of doors, from tree or mountain top to the lowest dip of the valley, clad in one stretch of white, is to see a beauty which dwellers in the tropics cannot realize. There are many phases of snow landscape. The snow may look a dull flat gray under a leaden sky, or it may sparkle frostily under a clear sun. The trees may stand up, gaunt and bleak, from ground deeply buried in snow, or the merest film of hoar frost may coat every tiniest twig and every blade of grass. Every bough may droop under a thick load of clinging white, or may be sheathed in a wrapper of clear transparent ice. Best of all the landscape looks when it may be traversed in a smoothly-gliding sleigh, with no sound in the frosty air except the tinkling of the horses' bells.

What mighty changes winter brings in the plant and animal world! How entirely different are the demands the winter makes on them as compared with the remaining seasons, during which the sun not only shines, but diffuses energizing heat! In the plants these changes appeal directly to the eye. All have apparently suspended their vitality; of the trees, only the pines and a few shrubs have retained their green dress; in the case of the others, the leaves have all disappeared. The buds, to be seen everywhere on the branches, are carefully enveloped in tight coverings, which in spite of their slight thickness allow no frost to touch the tender fabric they protect; all movement of the sap in trunk and twig is stopped, the tree is in a complete state of rest, in which the rigors of winter cannot affect it. The great array of annual plants has disappeared, withered and dried up; but under the soft snow lie the seeds, which owing to the fat they contain and their solid shells, are proof against the cold; or, the entire life of the plant has withdrawn into the root corpuscles, which, buried deep in the earth, survive the hardest winter.

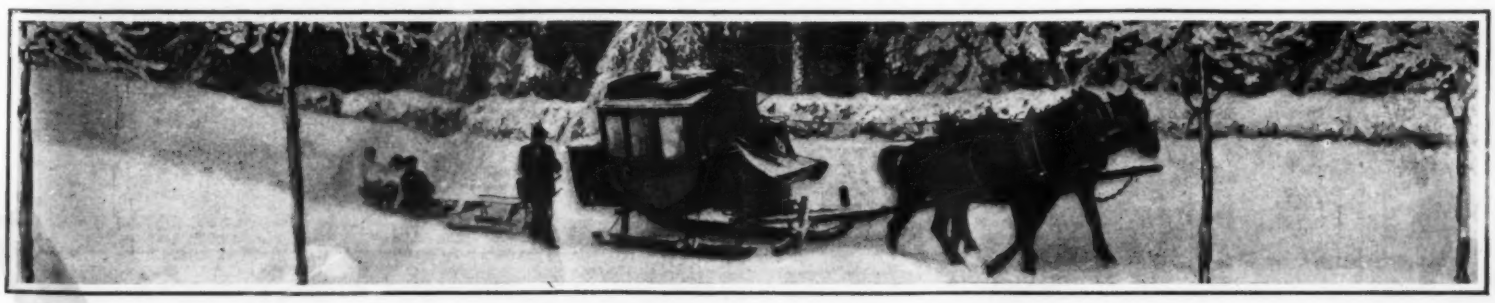
How is it, however, with the animal world? How do all its creatures with their thousand-fold different vital requirements get through the severe winter? The numerous and varied army of the insect world, that in summer so often announces its presence to the human being in the most emphatic manner, has disappeared from the face of the earth. If, however, we go into the forest and lift here and there the thick carpet of leaves lying under the snow, we shall be astonished to find all sorts of beetles, wasps, flies, and spiders, that have retired to this sheltered spot to winter. At the advent of cold weather they gradually become rigid, and remain in this condition until spring. The majority of the ephemeral insects, however, pass the winter in the larval or chrysalis state, in protected places, as in the earth, the wood of trees, etc.

Some common butterflies, for instance, always winter in the chrysalis form; numerous grasshoppers and many butterflies live through the winter in the egg state; other insects which require several years for their development—cicadas, stag beetles, etc.—are, of course, in the larval state.

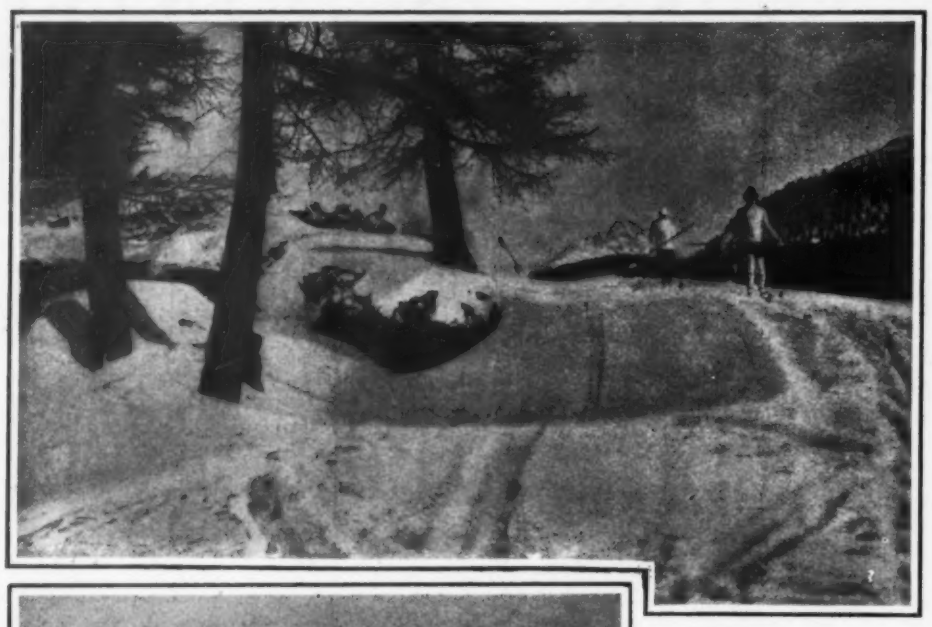
Creeping things, of low organization for the most part, bury themselves in mud or earth, or seek sheltered caves and holes in which they pass the winter. Lizards creep into holes under stones and bushes and lapse, soon after the advent of frost, into a condition of rigidity. Snakes do the same, often knotted together in a ball, lying motionless until the spring. That all these animals, the blood heat of which depends on the temperature of the surrounding air, should, when the latter falls below the freezing point, lapse into rigidity, and in this condition of apparent death pass the entire winter without taking any nourishment, is not surprising if we remember that when in a wakeful, perfectly lively condition, they can abstain from food for months without injury. It is peculiar and in every respect remarkable that this condition of rigidity, for the purpose of winter protection, occurs also in the case of warm-blooded animals, in other words, animals that lead a much more active life, animals whose consumption of oxygen is very much greater than that of the before-mentioned cold-blooded reptiles.

The faculty of thus protecting themselves is pos-

* The winter scenes accompanying this article are reproduced through the courtesy of Illustrirte Zeitung.



A QUAINT GERMAN STAGE COACH; HERE BODY IS TRANSFERRED FROM WHEELS TO RUNNERS WHEN THE SNOW COMES.



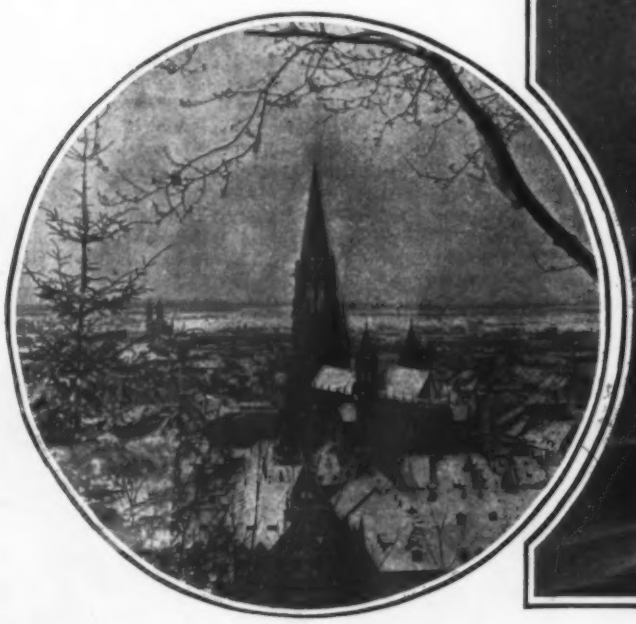
THE CONTRAST OF THE DARK PINE AND THE BRILLIANT SNOW.

THE LONG, BLEAK STRETCH OF A MOUNTAIN SIDE.

SNOW AND HOAR FROST IN GROTESQUE COMBINATION.

sessed by but a limited number of mammals; the best known among them include the bear, badger, woodchuck, hedgehog, and dormouse. All these animals betake themselves, with the commencement of winter, to more or less sheltered places. Bats assemble in caves, clefts in the rocks, in old deserted mines and tunnels; dormice and hedgehogs make nests in hollow trees, cracks, or in the thick layer of leaves under a brush; while the badger and the groundhog construct elaborate burrows, which they carefully close, from the inside, against the cold. No matter what the hiding place, in all of them, soon after the beginning of frost, the same conditions may be seen. The animals that have retreated, well nourished and quite fat, into their winter quarters, lie rolled up, with closed eyes, in a sound sleep. Gradually the activity of the lungs decreases, the breathing becomes slower and slower. The number of respirations falls off to 15 or 20 in a whole hour; in consequence, the blood heat of the body sensibly declines, usually to about the temperature of the surrounding air, which as a rule is about 50 deg. F. The stomach and intestines are empty and shrunken together, all organs cease to exercise their functions. The animal is consequently in a condition hardly to be distinguished from death. This reduction of the vital activity almost to zero alone makes it possible for warm-blooded animals to exist so long without nourishment.

In addition to these genuine hibernating animals there are a few that enjoy an interrupted winter sleep. The squirrel sleeps for weeks in his nest, but comes out on fine, clear days to look for food. It is the same with some kinds of bear, in whose case it must be noted that the female bear usually brings forth her cubs in the month of January, and after their birth remains with her helpless offspring in her "arms," uninterruptedly asleep, without taking any nourishment. By far the larger number of mammals, however, do not possess the faculty of being able to pass the winter without nourishment; on the contrary, the cold weather materially stimulates their appetites, and only with the aid of substantial food are they able to withstand the winter, protected from the cold by the heavy winter coat provided for them. The putting on of a thick, warm coat is the ordinary protection, and is so recognized in the case of all land animals. We speak of a summer coat and a winter coat in connection with almost



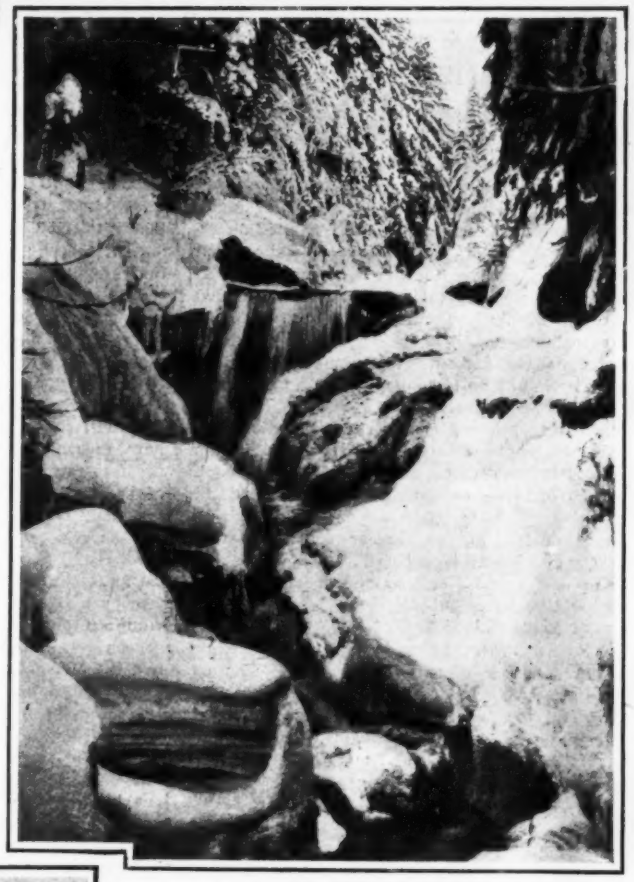
THE PICTURESQUENESS OF SNOW ROOFS.

WIND, SNOW, FROST, AND THAW ALTERNATING WEAVE SOME WEIRD SHAPES.

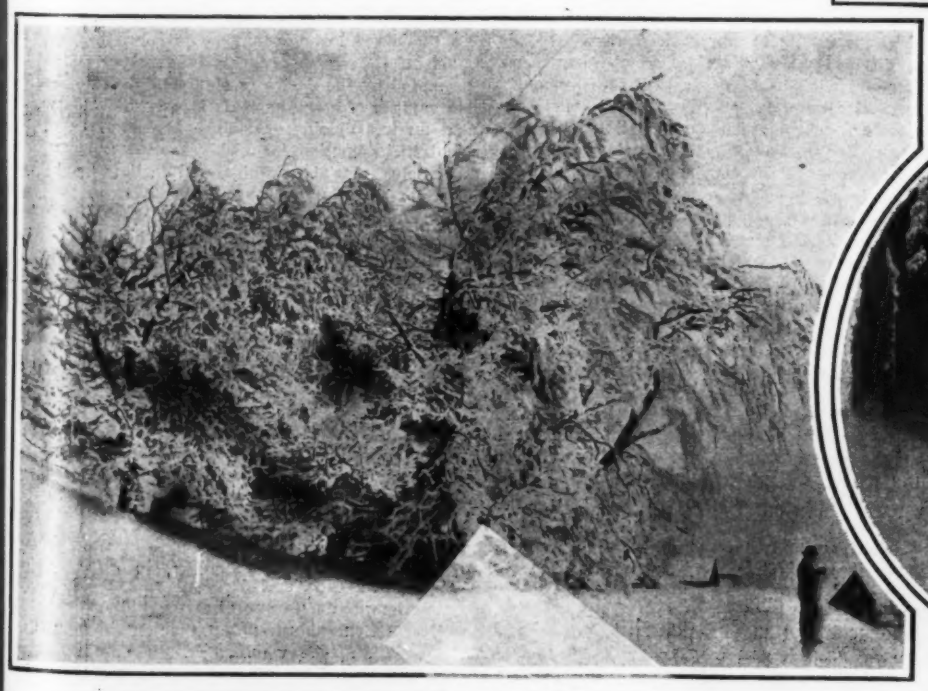
FAUNA AND FLORA IN WINTER.

MAGNIFICENT SNOWSCAPES ARE SEEN FROM RISING GROUND.

LARCHES AND PINE RISE GAUNTLY FROM THE SNOW.



AN ICE FRINGED STREAM.



THE FEATHERY DELICACY OF SLENDER-LIMBED TREES CONTRASTS WITH THE HEAVY MASSES CLINGING TO THE PINE NEEDLES.

all mammals. The summer coat consists for the most part of bristle hair. The winter coat is of dense wool, that toward the winter season begins to grow under the bristle hair, and speedily, with its thick substance, overlays the summer coat. With most animals, also, the hair changes color. It becomes much lighter, even quite white, and being of the same color as the snow, it insures its wearers the greatest protection against pursuit. I need only call attention to the ermine and the snow hare.

Protection against winter by change of coat, so universal among the mammals, is less common among the birds. The birds that remain over winter acquire, it is true, a thicker covering; the soft, woolly down is more abundantly developed, the entire plumage becomes thicker and warmer.

By far the greater number of our domestic birds protect themselves against the inclemency of the winter by migrating to warmer countries. In the autumn the migratory birds assemble and at a certain well-defined period they leave us and make their way south. Most of the wanderers travel only at night, though some, especially the large birds, fly by day, and we may occasionally see them, in regular order, moving southward at a considerable altitude. In consequence of this migration, northern bird life in winter is but poor compared with the numbers of the bird population in the summer time.—Abstracted from Illustrirte Zeitung.

RESTORATION OF MUMMIES.

SEVERAL years ago, Prof. Harris H. Wilder, of Northampton, while preparing the skeletons of embryos, following Schultze's method, made the interesting observation that these specimens, although shrunken by their immersion in alcohol, regained their normal dimensions and forms as soon as they were placed in a 3 per cent solution of caustic potash. The experimenter supposed from his observations that this solution would exercise analogous effects on animal tissues deprived of their water by drying in the air; an experiment made on the dried body of a frog demonstrated the truth of his conclusions. This success encouraged him to apply this same method to the

FAUNA AND FLORA IN WINTER.

restoration of mummified human corpses. The following process gave truly surprising results.

The object is placed immediately in a reservoir containing a solution of one-third of 1 per cent of caustic potash, under the surface of which it is kept until it becomes perfectly soft. The mummified tissue, which at first floats on the surface of the liquid, rapidly imbibes the latter and sinks gradually. The object must be watched very carefully during its stay in the liquid, so as to take it out as soon as it shows the least sign of decomposition. A partial disintegration cannot be avoided in parts putrefied before the drying. The duration of this operation varies between twelve and forty-eight hours.

After having taken it from the solution of potash, the tissue is then placed for a certain length of time in water, where it often continues to swell still further. It is necessary to use the greatest precautions during this stage of the performance. In order to avoid an excessive swelling (conducive to the disintegration of the tissues), Mr. Wilder advises that the object be plunged, as soon as the treatment is sufficiently far advanced, in a 3 per cent solution of formaline, which exerts a fixative action, opposing all later alterations; it is also convenient to leave the subject in this solution when it is finally prepared for observation.

Mr. Wilder has succeeded in restoring, in a very satisfactory manner—and even in establishing, with a certain approximation, the color of the skin—a Peruvian mummy from the Peabody Museum. All the tissues took again their natural consistency in such a manner as to allow perfectly of microscopic examination. Under the skin, the experimenter discovered the presence, in great numbers, of little cells of grease, the slightly flattened form of which showed the relative insufficiency of the restoration, since the corresponding parts of the living individual must have been a little more strongly expanded.

Some heads of infant cliff dwellers, dried in the sun without the application of any embalming substance, were also treated with success. The different parts of the face, unrecognizable and almost entirely defaced before the treatment, reappeared with a clearness almost as great as in the living individual. Mr. Wilder also proved that the hairy skin of one of the children was covered with eczema.

The mummies of several adult individuals belonging to this same tribe were restored with an equal success, while bodies embalmed after the Peruvian fashion were found to be preserved only on the surface, while the deep parts were entirely decomposed. Mr. Wilder draws the conclusion that drying in the sun, or even in mountain air, is preferable to the embalming practised by the Peruvians.

Moreover, Mr. Wilder hopes to realize even better results by the restoration of Egyptian mummies which are the best preserved; thus, he can probably restore in all their reality, the features of the most ancient Pharaohs.

The scientific importance of this method rests in the possibility that it gives of submitting mummified tissues to a rigorous anatomical examination.

AERONAUTICS IN 1908

A FORECAST OF PROGRESS.

BY OUR LONDON AERONAUTICAL CORRESPONDENT.

PROBABLY in the whole history of aeronautics no year has been entered with such high hopes as 1908, for this year has begun with the certain knowledge that aerial navigation is no longer a fantastic dream. The experiments and trials which were carried on up to the very end of 1907 were not successful enough to be conclusive, and yet they gave sufficient encouragement to the pioneers to press on with redoubled vigor.

That aeroplanes and dirigible balloons should have been tested in such a month as December, 1907, is a clear indication of the indomitable pluck and determination of the aeronauts, for up to a short time ago it was generally believed that aerial navigation was a fair-weather pastime, only to be attempted in the summer months. As it was, work went on all through 1907, though of course no actual flights were made in rough weather. The air was taken on every available opportunity during all the seasons, and in stormy weather the time was occupied in putting finishing touches to new models, or making experiments and improvements indoors.

It is with a genuine feeling of relief that we look back on the past year, for it seemed that the new science would take a heavy toll of human life as experimenters became more numerous and more daring. But wonderful to relate, not a single life has been lost in aeronautical work, as distinguished from mere traveling in drifting balloons. The dirigible balloons and the aeroplanes have been the cause of many accidents, but not one life has been lost. There were, needless to say, several marvelous escapes; but when we bear in mind that in previous years, with far fewer aeronauts at work, several lives have been lost and few successful achievements accomplished, it would seem that mere luck has not been the main factor in keeping the death roll blank during 1907. Taking even the most optimistic view of 1908, it can hardly be hoped that such a record will be equaled, for we are now entering a very dangerous stage. The success of the leaders will tempt many unskilled imitators to rival them, and, just as in the early days of automobilism, many accidents will result through inexperienced men taking charge of machines which they are unfitted to handle.

Then again each little success will tempt expert aeronauts to try their luck further, and thus they will leave themselves open to one of the many unexpected occurrences which bring disaster in every branch of locomotion. Our knowledge is yet very far from complete as to the strength of the various apparatus, and the air as a medium is peculiarly treacherous, owing to its physical properties. But at least the nature of these risks is now more fully understood by experimenters, and the fundamental fact has been demonstrated that human flight is possible. The enthusiasm of aeronauts is sufficient to guarantee that the work will henceforth be pursued unremittingly, even though a succession of disasters should occur, and public confidence for the time be shaken.

In the present year most interest will attach to the aeroplane experiments, and 1908 may reveal many grand secrets to us, and stand forth as the year in which the aeroplane or the heavier-than-air machine became really practicable. The year 1907 ended in tantalizing fashion. It was hoped all through that the Wright brothers would make some public demonstration in Europe, whither they had gone with the ostensible object of selling their plans. But no such trials were made, and eventually many people expressed themselves as skeptical of the Americans' claims. But I have always strongly believed in their work, and I felt it was merely an error of policy on their part which prevented them last year from proving their position as leading exponents in the art of the aeroplane.

Since their last public trials much progress has been made by other experimenters, and for one thing better and lighter engines are now being employed than those with which the Wright brothers made their sensational flights in 1905. But I cannot agree with the critics who assert that the Wrights have now been outstripped in the race by other aeronauts, and I have reason to believe that in 1908 they will give proof to the world of the marvelous skill which years of practice and experiment have given them. There are many other American workers, too, who may any day surprise the world with an epoch-making discovery.

Of the European aeronauts, Henri Farman has been the most successful. His latest achievement was the winning (on the 13th ultimo) of the Deutsch-Archdeacon prize for flying over a kilometer circuit. He had twice achieved this result unofficially in 1907, and it was hoped that ere the year closed he would have succeeded in making the record before the judges who must be present on such an occasion. The winning of this prize will be but one step in his progress, and he is rapidly gaining that experience which may enable him ere the end of the year to set up many records. The engine has been his main trouble so far, for the usual type of gasoline motor seems to behave very erratically after working in the air for some time. Something is now understood of the peculiar conditions which obtain in aerial locomotion, and with more reliable motors many of the aeronaut's difficulties will disappear.

Of the other workers, such as Bleriot, Esnault-Pelterie, Ferber, Santos Dumont, Vuia, and Gastambide-Mengin, much may be expected, though so far they have not achieved the success of Farman. This, the French school, is exceedingly active, and from the many crude and hastily evolved ideas something really practicable may result, which will advance the aeroplane considerably. In England less progress is being made, and most of the work is done with models. Roe is perhaps the most promising experimenter, but the military authorities are testing a large machine in the Highlands of Scotland, from which much is expected. Bearing in mind the fate of the British military airship last year, one should be reserved, however, in hoping that the military experimenters will achieve much in aeroplane work just yet.

Turning to the dirigible balloon section, we may expect to find dirigible balloons actually placed on military duty on both sides of the Franco-German frontier this year, and the fleet of vessels will thus add a new factor to the military situation. Italy is also building a military balloon, and the ill-fated British dirigible is being patched up and modified, in the hope of being made the equal of the French and German vessels. The parsimony of the British Treasury, which has hitherto hampered military aeronautical work in England, may, however, be altered, and if so, the British authorities may be able to evolve a more successful vessel. America has some headway to make in this branch, but 1908 should see her very active. Indeed, I look to America for much of the development which will be made during the year.

Certain it is that the great powers will have to seriously provide for this new engine of war, and with inventors stimulated by international competition, very many improvements may be expected. At present the "Patrie" type of vessel is the most favored, but the Zeppelin rigid-envelope airship may eventually lead to important modifications, especially if speed and power against the wind are to be reckoned of primary importance.

On the other hand, artillerists are active in preparing for aerial warfare, and already Germany has designed a motor car carrying a new gun which can be tilted up to seventy degrees when being used against airships. The speed and ubiquity of such a car will render it imperative that airships have a high ascensive power so as to keep out of range, and in this respect the "Patrie" type of vessel is superior bulk for bulk, to the Zeppelin.

The equipment of the vessels, the building of aerial harbors, the invention of aerial artillery, and the creation of various types of vessels, such as small ships for reconnoitering and dispatch carrying, large vessels as destroyers of the smaller, and still larger types for raids and attacking purposes, will make much progress—on paper at least—during the year, and by the following year warfare may be well nigh revolutionized.

The year 1908 opens with the dirigible balloon holding long distance and speed records, and most in favor with the military experts, but ere the twelve months have closed, the aeroplane will probably have secured the high-speed record, and may have signally displayed its utility in many forms of military work. To the peace lover it may be rather regrettable that much of the recent progress in aeronautics has been prompted by the desire to obtain new and more terrible engines of war; but this is only a passing phase and an unavoidable one, since almost every development in locomotion is quickly availed of by military scientists. Aerial warships will make warfare more terrible, and thus perhaps cause nations to ponder more ere they fly at each other's throats. But as for the other reasons why aeronautics should be pursued, no thought need be given here, for the fact remains that the work *will* be pushed on independent of the material advantages which are to be derived.

SIMPLE METHOD OF CONVERTING ORDINARY PHOSPHORUS INTO THE RED AMORPHOUS FORM.

THE following method allows the transformation of yellow to red phosphorus to be conducted readily as a lecture experiment, without the least danger. It is based on the observation of Brodie in 1852 that this transformation is accelerated by the presence of iodine. Some fragments of dry phosphorus are introduced into a tube, sealed at one end, about 30 centimeters long and 7 to 8 millimeters wide, so that when melted the phosphorus fills a space of about 10 centimeters. The tube is plunged into a sulphuric acid bath and heated to 180 deg. C. A small particle of iodine is then dropped down on the surface of the phosphorus. As this sinks through the melted mass the immediate transformation of the yellow phosphorus to the red form takes place.—Zecchini, Gazz. Chim. Ital.; J. Pharm. Chim.

THE MOTHER SUBSTANCE OF RADIUM.

IS THORIUM THE PARENT OF RADIUM?

BY OTTO HAHN.

As our knowledge of the nature of radio-active phenomena has grown, we have reached the conviction that even radium, which is apparently unchangeable, cannot keep its activity for ever, but that in course of time it must be converted into another inactive product.

Different views are at present held regarding the time which radium takes to undergo this change. The highest value for the decay period—the time in which a given quantity of radium decays to one-half—is 2,600 years.

Owing to the great age of the solid crust of the earth, radium would have disappeared long ago, even if the whole earth had consisted of it alone, if we did not suppose that radium itself is continually formed afresh.

This supposition has been fully confirmed. The parent substance of radium is undoubtedly uranium, which undergoes a far slower transformation. It is also certain that one or more intermediate products must exist between uranium and radium, and thus uranium, or rather the so-called uranium X, cannot be the immediate mother substance of radium. A great many investigators have for some time been engaged in the search for this intermediate product.

At the end of 1906 Boltwood (Phys. Zeit., vii., 915) announced that he had succeeded in showing that actinium, which had then been known for some time, was the mother substance. An actinium solution prepared by Boltwood undoubtedly showed an increase in the radium present in it after some months.

Shortly afterward Rutherford (Nature, lxxvi., 126) proved that it was not the actinium itself, but an unknown product occurring with actinium, which produced radium. Giesel, Soddy, Meyer, and v. Schweidler all showed that actinium itself could not be the mother substance.

In a letter to Nature (September 26, 1907) Boltwood described new experiments, confirmed Rutherford's result, and also stated that the hypothetical substance followed the reactions of thorium, and thus must be able to be easily separated, by the aid of these characteristic reactions, from actinium, which resembles lanthanum. In a letter to Nature (October 10), he confirms his supposition, and states that the new substance emits α-rays of a low penetrative power. The product is thus proved to be a new element; Boltwood calls it "ionium."

In reference to this subject I wish to report shortly on experiments which were not quite concluded when Boltwood's statements were published, but which in another perfectly independent way showed that the mother substance of radium follows the chemical reactions of thorium, and can thus be separated with the latter from minerals containing uranium.

In the investigation of a new intermediate product in thorium, which I called mesothorium, I noticed that older "pure" thorium preparations contained relatively large amounts of radium. This was peculiar, for the substance used for the preparation of the thorium, monazite sand, contains only very small amounts of uranium. Naturally only a very small amount of radium corresponds to the small amount of uranium, and this must have been separated from the thorium in the complicated process of preparing pure thorium salts.

Some months ago I therefore began a systematic examination of different old pure thorium preparations to determine the amount of radium they contained. A weighed quantity of pure nitrate was dissolved in pure water, boiled to remove all the radium emanation, and then corked up in a little flask. After a sufficiently long time the contents of the flask were again boiled, the gases were collected in a burette, and some time after, when the thorium emanation had decayed, blown into a suitable electroscope. By comparison with an accurately known quantity of radium under the same conditions in this way the amount of radium present in my thorium nitrate solutions was determined.

I had at my disposal specimens of very different but known age, placed at my disposal by the firm Dr. O. Knöfler, of Berlin. As result I found that the specimens contained more radium the older they were, the oldest specimen of the year 1898 containing the most.

Then I obtained from the firm 100 grammes of quite freshly prepared thorium nitrate. The amount of radium in it was exceedingly small; the whole quantity of 100 grammes of the substance was used to measure it accurately. When referred to equal quantities of thorium the radium present in the new solution was scarcely 1-100 of that in the specimen nine years old.

It could not be assumed that the impurity of the older preparations was the cause of the greater amount of radium present, and it is just as improbable that thorium itself slowly decays to radium. Therefore I assumed that in the technical preparation of thorium another active substance was separated with it. This substance decays to radium, and is thus the long-sought direct mother substance of radium. In order to prove this, at the beginning of August I arranged the following experiments:

1. One hundred grammes of thorium nitrate, obtained directly from the factory as perfectly fresh, were tested for radium in the way described above, after standing for four days. The result was calculated to the equivalent quantity. It was closed up on August 17, and again tested on October 10. The amount of radium was twice as large as before.

2. Forty grammes of thorium nitrate, prepared at the end of April, 1907, were also examined accurately for radium, allowed to stand over the holidays, and tested on October 11. This amount also showed a considerable increase in the quantity of radium present.

3. Fifty grammes of thorium nitrate, prepared in June, 1907, were precipitated with oxalic acid from acid solution, the radium in the filtrate determined, and again it was allowed to stand over the holidays, and tested in October. In this case there was no increase in the amount of radium. Thus the mother substance is contained in the thorium precipitate. This was accidentally mixed with another preparation, and therefore was not examined further.

4. About 1 milligramme of radio-thorium (activity about 100,000) was as carefully as possible freed from the small percentage of radium it contained by precipitating it three times with ammonia, and the remaining trace determined on August 15. The specimen gave the same result on October 14. The radio-thorium had been prepared from thorianite by precipitating with barium sulphate, and thus could not contain the mother substance of radium, which agrees with the above result.

In order to show the order of magnitude of the amount of radium found in some specimens, I append a few results. The quantity is referred to 100 grammes of thorium nitrate.

One hundred grammes of nitrate which had been obtained a few days before from the factory as only just prepared, contained about 3×10^{-11} grammes of radium bromide. The instruments I had did not allow me to determine the exact amount more accurately.

100 grammes July, 1906, contained 5.5×10^{-10} grammes
100 grammes Feb., 1902, contained 2.8×10^{-8} grammes
100 grammes Feb., 1900, contained 4.1×10^{-8} grammes

The measurements were carried out with 10 grammes of the substance, except in the case of the perfectly new specimen.

Control experiments with other specimens of thorium are also being arranged.

If the amounts of uranium and thorium present in monazite sand are known, and if it is assumed that the total quantity of thorium and the total quantity of the mother substance of radium are obtained in the thorium preparation, it can be calculated how many grammes of radium are contained in a given amount of thorium nitrate if there is equilibrium between the radium and its parent substance in the thorium.

Now the quantities of uranium and thorium in different specimens of monazite sand, even in those from the same place, vary within certain limits. But it may safely be said that the average amount of uranium in Brazilian monazite sand is 0.3 per cent, and of thorium oxide, roughly, 5 per cent. The amount of thorium is frequently rather higher, but it must not be assumed that the thorium is quite quantitatively extracted in its preparation. Thus, 5 per cent is certainly the right order of magnitude. Now, 1 gramme of uranium in any uranium mineral contains, roughly, 0.65×10^{-6} grammes of radium bromide. By a simple calculation it may be found from the above assumption that 100 grammes of thorium nitrate + the mother substance of radium in equilibrium with radium must contain, roughly, 2×10^{-6} grammes of radium salt (calculated as bromide).

From this number, and the values obtained above by purely experimental methods for the amount of radium in different specimens of thorium of known age, according to the equation $I/I_\infty = 1 - e^{-\lambda t}$, the constant λ can be calculated, and from λ the decay period of radium. Hence, the values found for the decay period from the above results for three different thorium specimens are 3,250 years, 2,840 years, and 2,630 years. As only a mean value is assumed for the amounts of uranium and thorium present, naturally variations in them cause corresponding variations in the decay period. Until more exact measurements are made the values can only be regarded as giving the order of magnitude of the decay period, and can lay no claim to great accuracy. The values found differ widely from a value recently determined by Cameron and Ramsay (Journ. Chem. Soc., xci., 1266) for the decay constant of radium; for these investigators, from the volumes of the emanation developed from radium in a given time, deduced for the mean duration of life of radium 236 years, which gives 163 years for the decay constant. On the other hand, the numbers given above agree satisfactorily with the value 2,600 years found by Rutherford. No explanation of the great difference in Rutherford and Ramsay's numbers is as yet forthcoming. Further researches with the newly discovered mother substance of radium will give an explanation of this important question.

Owing to the characteristic properties of "ionium" this new element can easily be completely separated from uranium minerals which contain little or no thorium; with my thorium preparations from monazite sand, which is so poor in uranium, or from monazite itself, it was not possible to get a pure product, as a method of separation from thorium is not known.

The part of pitchblende which follows the reactions of thorium will provide the cheapest material for the more thorough investigation of the new substance.

I beg to offer my best thanks to the Jager Foundation, of Berlin, for furnishing me with means for the above research.—Berichte, xl., 4415.

INCREASE OF TEMPERATURE IN THE INTERIOR OF THE EARTH.

THE problem of the increase of temperature in the interior of the earth was discussed by Prof. Königsberger at the last Congress of German Naturalists and Physicists.

A uniform temperature is known to reign at a comparatively small depth below the surface of the earth, independently of the time of day or year. This temperature is only a little higher at normal altitudes than the average annual temperature of the air (being lower in summer than the outside temperature and higher in winter). Cellars are accordingly the most usual storerooms for food liable to alteration under the influence of rapid variations of temperature.

The fact that the temperature of our earth at greater depths is above the outside temperature was recognized as far back as 1662 by Kirschner of Fulda. According to the author, recent measurements made in this connection should be subdivided into several categories, according as the regions considered are, first, below level ground, at considerable distance from mountains and large water masses, or in sediments; secondly, below mountains and valleys (in tunnels); thirdly, in the neighborhood of considerable water masses; fourthly, in countries of recent volcanic origin; fifthly, in coal, paraffin, or ore fields. For purposes of calculation it is quite indifferent whether the warmth of the earth is produced by cooling or by radio-activity. Calculations of the increase in temperature below mountains, such as were made in the cases of the Gotthard, Simplon, and Mont Cénis tunnels, were found to agree very well with the increase actually experienced, thus showing the possibility of predetermining the temperature of new tunnels. In the neighborhood of large water masses (coasts of Holland, England, Australia) the increase of temperature is considerably reduced by the heat conduction of the water. Measurements of the temperature increase in countries of recent volcanic origin allow the depth of molten lava to be calculated. A simple calculation further shows the activity of a volcano to be increased very strongly by a rise in temperature at the center of its crater.

Prof. Königsberger has designed an apparatus for registering oscillations of lava by means of variations of temperature, thus predicting a possible eruption of volcanoes. Above coal fields the increase in temperature is very great, though soon assuming normal values below the latter. These conditions of temperature, while varying from one case to another, can always be determined by calculation. The generation of very small quantities of heat usually suffices to produce a considerable increase of temperature in mines.

SIGHT IN THE LOWER ANIMALS.

A DESCRIPTION OF PRIMITIVE OPTICAL ORGANS.

BY PROF. R. HESSE.

IN the sense of Max Schultze's generalized definition of sight as "the transformation of the motion which constitutes light into the motion which we call the transmission of nervous impulses," it is legitimate

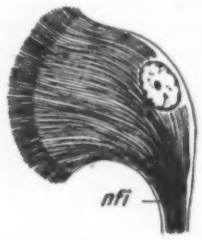


FIG. 1.—VISUAL CELL OF EARTHWORM WHICH MERELY DISTINGUISHES LIGHT FROM DARKNESS.

nfi. Nerve fiber.

to speak of sight in the lower animals. Five degrees of sight may be distinguished:

1. Mere discrimination of light from darkness, in which only the intensity of the light, but not its direc-

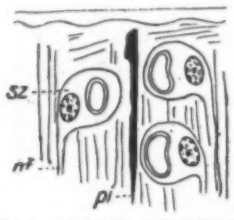


FIG. 2.—VISUAL ORGAN OF BRANCHELLION, A SPECIES OF LEECH, WHICH VAGUELY PERCEIVES DIRECTION OF LIGHT.

sz. Visual cells. *nf.* Nerve fibers. *pi.* Pigment screen.

tion or the form of its source, is perceived (Fig. 1). 2. Directional vision, in which rays coming from different directions produce different excitations (Fig. 2). 3. Perception of motion (Fig. 3). 4. Appreciation of

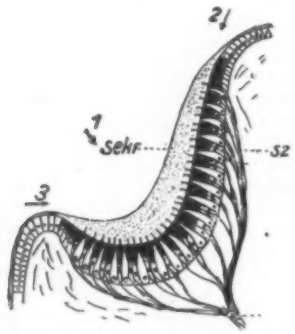


FIG. 3.—EYE OF LIMPET WHICH PERCEIVES MOTION AND ITS DIRECTION.

sz. Visual cells. *sekr.* Vitreous secretion.

distance (Fig. 4). 5. Pictorial vision, in which the form of the luminous object is distinguished, as it is in most of the higher animals (Fig. 5).

In all organs of vision the receptive elements con-

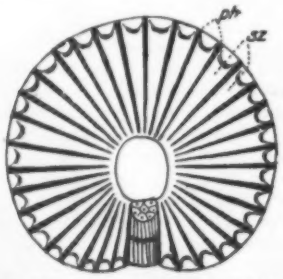


FIG. 4.—EYE OF TUBE WORM (BRANCHIOMMA) WITH RUDIMENTARY PERCEPTION OF FORM.

sz. Visual cells. *ph.* Pigment.

sist exclusively of primary sense cells in which nerves terminate, while in other organs of sense we find also secondary sense cells which are surrounded by free nerve terminations with which they are not directly connected. Visual sense cells contain modified nerve terminations which appear to act as transformers, converting the stimulus of light into a form capable of affecting the visual cells themselves, for animal protoplasm is not directly sensitive to light, although it is affected by mechanical, chemical, and thermal influences.

On the other hand, the dark pigment so commonly present in organs of vision cannot act as a transformer, for it is absent from the visual organs of many animals. Its function is that of a screen which

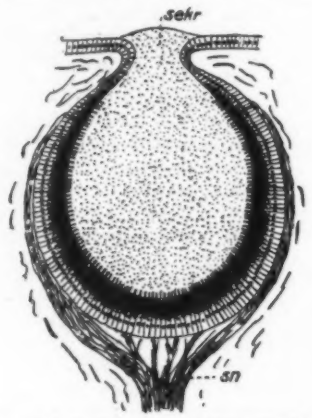


FIG. 5.—EYE OF ABALONE, SHOWING TRANSITION TO TYPE OF EYE OF HIGHER ANIMALS.

sekr. Vitreous humor. *sn.* Optic nerve.

cuts off rays coming from certain directions and admits rays from other directions, thus limiting the visual cell to stimuli of a single definite kind, or a few kinds.

In the entire absence of pigment, rays coming from many directions reach the visual cells and produce equal effects if they are equal in intensity. In this case sight is limited to the discrimination of light from darkness (Fig. 1). Of this kind is the sight of earthworms, which have numerous visual cells distributed through the skin, especially near the head. Their simple vision suffices for their simple life.

The most rudimentary pigment screen is found in *Branchellion*, a leech-like parasite of the torpedo or electric ray, in which the pigment is arranged in a vertical sheet between the front and the back visual cells (Fig. 2). Light from in front strikes only the front cells, light from the rear strikes only the back cells, while light from the sides or from above reaches all the visual cells. Hence, a very imperfect directional vision is added to the discrimination of light from darkness.

The perception of direction is greatly improved when

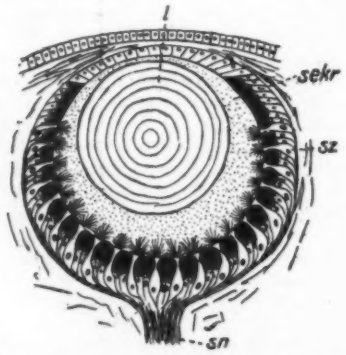


FIG. 6.—EYE OF COMMON SNAIL WITH RUDIMENTARY LENS.

sz. Visual cells. *sn.* Optic nerve. *sekr.* Vitreous humor. *l.* Lens.

the pigment nearly surrounds the visual cells as it does in the "pigment cup ocelli" of many compound eyes. The deeper the cup and the smaller its mouth, the more effective is the optical isolation of the visual cells which it contains. Some compound eyes of this type are composed of numerous ocelli, each of which contains a single visual cell, while others have few ocelli, each containing many visual cells. The simplest ocelli are so arranged that their axes diverge, the limitation of the fields of vision of the individual ocelli being compensated by their number. Besides improved directional vision, such eyes possess perception of motion, for a moving luminous point successively affects a series of cells in an order which depends on the direction of motion. The best of such compound eyes contain many deep and narrow ocelli, packed closely together, as in the eyes borne by the gills of the tube-

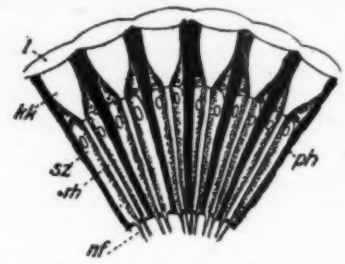


FIG. 7.—PORTION OF FACETED COMPOUND EYE WHICH FORMS DISTINCT MOSAIC PICTURES OF VERY NEAR OBJECTS ONLY.

l. Cornea lens. *kk.* Vitreous cone. *sz.* Visual cell. *rh.* Rhabdoma. *nf.* Nerve fibers. *ph.* Pigment envelope of element.

worm *Branchiomma* (Fig. 4). A luminous surface within the general field of view of such an eye affects various ocelli, the number and arrangement of which depend upon the position, size, and shape of the surface, thus making possible a very rudimentary sort of pictorial vision. The general picture results from the

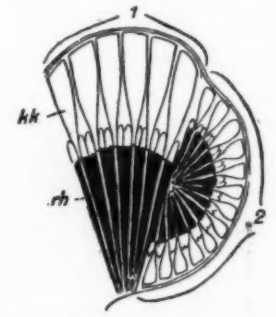


FIG. 8.—EYE OF CRUSTACEAN (BYTHOTREPHES).

Part 1 for distinct vision in small field. Part 2 for indistinct vision over wide field. *kk.* Vitreous cones. *rh.* Rhabdoma.

combination, or opposition, of the several minute fields of excitation, as a mosaic is composed of colored bits of stone. The distinctness of the image increases with the number of ocelli, but the picture is never bright, because very little light from any point of the object

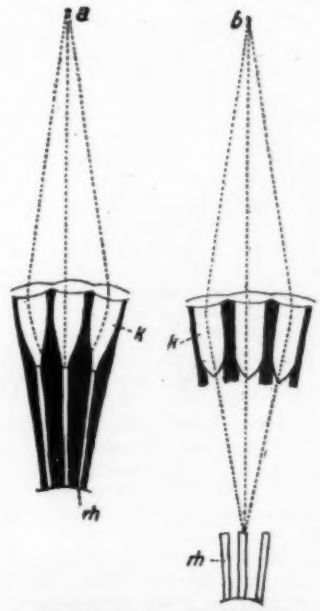


FIG. 9.—FORMATION OF IMAGE (*a*) BY APPOSITION, (*b*) BY SUPERPOSITION.

kk. Vitreous cones. *rh.* Rhabdoma.

can penetrate into the ocellus opposite that point, and none reaches the other ocelli.

Vision is still more imperfect in an eye composed of few ocelli, each of which contains numerous visual cells. Such is the concave eye of the limpet (Fig. 3).

in which rays nearly parallel to the general axis affect all, and oblique rays affect part of the ocelli.

But the shallow, epithelial ocellus of the limpet is the starting point of an important development. In the nearly related abalone or sea ear (*Haliotis*) the cup becomes deeper and more globular and the secretion, which in the limpet merely covers the sensitive end of the visual cell, expands until it fills the cup and protrudes beyond it, forming a convex lens which converges to one point all the parallel rays that fall upon it (Fig. 5). In another group of gasteropod mollusks, the snails, and also in annelid worms, a spherical lens is formed in the interior of the mass that fills the nearly closed cup (Fig. 6), and lenses are developed in a somewhat different way in the eyes of articulate animals (insects, spiders, crustaceans, and millipedes).

An ideal lens converges to a point all the rays sent to it by any one point of the object. The addition of such a lens to an organ of vision causes all the light that comes to the lens from any point of the object to be concentrated on the visual cell that lies opposite that point, and prevents that cell from receiving light from any other point of the object. This selective or distributive effect of the lens is similar to that which is produced by the arrangements of pigment previously described, and to this extent the simple eye provided with a lens resembles in function an eye composed of many pigment-cup ocelli. In the former, however, the impression is stronger because more light reaches the individual visual cells, the intensity of the effect being proportional to the size of the lens. The result is perception of direction and motion, or true pictorial vision, according to the number of the visual cells.

A complication is introduced by the fact that the distance of the object affects the position of its image, the image of a distant object being formed nearer the lens, or further forward, than the image of a near object. The impression made on any visual cell is most intense when the luminous point which causes its excitation (the point of the object which lies on a straight line drawn through the cell and the optical center of the lens) is at such a distance from the lens that the rays coming from it are converged to a point exactly on the sensitive part of the cell. Hence each visual cell is specialized for a particular distance as well as for a definite direction. Either a nearer or a more distant luminous point makes a weaker and less shapely localized impression, and thus arises a sort of perception or appreciation of distance. The eyes of cuttle fishes and vertebrates can be accommodated for distant vision of objects at various distances by means of changes in the form or the position of the lens. Few invertebrate animals possess this power of accommodation, but some of them have an imperfect substitute for it in the possession of two layers of visual cells, the cells which are in front, or nearer the lens, serving for distant vision while the posterior or more distant cells are used for the perception of near objects. This peculiarity is found in the eyes of scallops and in the frontal ocelli of dragon flies.

Ocelli furnished with lenses are found in many animals. When few in number they are capable of little more than the perception of direction. This is the case in some marine species of slug, or shell-less snail.

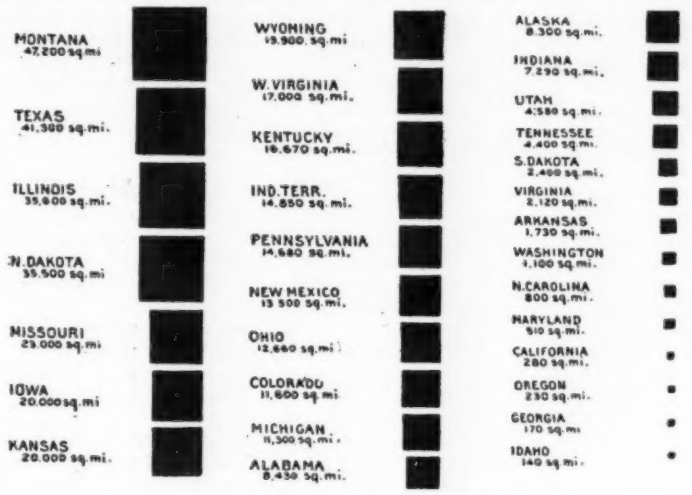
The compound faceted eyes of insects and crustaceans (Fig. 7) are composed of very numerous and closely aggregated ocelli, each of which is furnished with a lens. Each ocellus, or element of the compound eye, contains seven or eight visual cells arranged in the form of a tube with their sensitive ends directed inward. This tube is called a rhabdoma. The whole apparatus closely resembles in function the compound eye composed of pigment cup ocelli, without lenses (Fig. 4). The distinctness of vision is proportional to the number and the closeness of the elements, that is, to the number of them that are directed toward the object. In the compound eyes of the dragon-fly *Aeschna* (dragon flies possess compound faceted eyes in addition to the isolated frontal ocelli already described) the angle between adjacent elements varies from ½ degree at the top to 1½ degrees at the bottom of the eye. A rod 10 inches long and 14 inches distant from the eye subtends a visual angle of 40 degrees, and affects fifty, forty, or thirty elements, according as it is situated above, to the side of, or below the insect. In the cricket *Ascopis* the elements diverge so widely that only ten would be affected by the same rod at an equal distance. But a rod 10 inches long placed 14 inches in front of a human eye affects 2,000 retinal elements. In order to affect only fifty, it would have to be removed to a distance of more than 60 feet. This comparison shows that insects can see clearly only very near objects. The brightness of the image depends on the size of the individual lenses, which is inversely proportional to their number and a compound eye of given diameter. In many crustaceans a portion of the eye consists of very long and nearly parallel elements (1, [illegible] 8) and gives keen and distinct vision within a small field, while the rest of the eye, composed of shorter and more divergent elements (2, Fig. 8) serves the purpose of indistinct vision over a wide field.

In the typical faceted compound eye each element, comprising a lens, a conical mass of vitreous humor, and a sensitive rhabdoma, is completely isolated from its neighbors by an enveloping screen of pigment (*a*, Fig. 9), and the image is formed by apposition. In many species, however, only the front or outer portion of the pigment screen is found, and the refracting system is so constituted that several lenses converge upon a single rhabdoma rays from the point of the object that lies directly opposite that rhabdoma (*b*, Fig. 9). In this case the image is said to be formed by superposition.

The eyes of many crabs, moths, and beetles form images by apposition in daylight and by superposition at night, the pigment screens lengthening and shortening under the influence of light and darkness.

In deep-sea crustaceans, which live in continual gloom, the pigment never reaches the rhabdoma and the image is always formed by superposition.

Exner's experiments with fireflies have proved that, in the formation of images by superposition, the refracting parts of the compound eye act together as a unit, like the lens of the simple eye of vertebrates, and that the rhabdomas similarly take the place of the retina. Accordingly, we find another remarkable modification in the eyes of many deep-sea crustaceans, in which the rhabdomas are considerably more numerous than the lenses and vitreous cones, and the structurally compound eye becomes a single organ of vision.



COAL RESERVES BY STATES.

THE COAL RESERVES OF THE UNITED STATES.*

COAL may be divided into three main classes, anthracite, bituminous, and lignite, but in the trade these main classes are broken up into several groups, which are represented in the following diagram:

DIAGRAM SHOWING CLASS OF COAL.

Coal.....	Anthracite...	(*a*) Anthracite.
		(*b*) Semi-Anthracite.
	Bituminous...	(*c*) Semi-bituminous.
		(*d*) Bituminous.
		(*e*) Sub-bituminous.
	Lignite.....	Lignite.

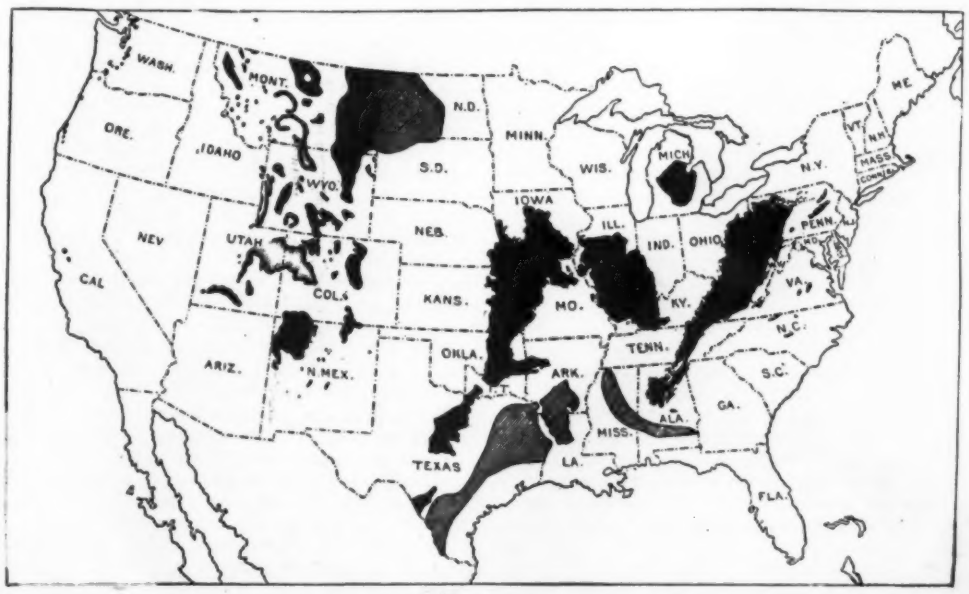
* Abstract of an address by Marius R. Campbell, of the United States Geological Survey to the National Geographic Society.

(*a*) Anthracite is too well known to need description. (*b*) Semi-anthracite is a low grade of anthracite. (*c*) Semi-bituminous is a high grade of bituminous, such as the George's Creek coal of Maryland, Pocahontas coal of Virginia and West Virginia, and the carboniferous coal of Arkansas. (*d*) Bituminous is the common grade of coal found throughout the eastern coal fields and in limited areas in the West. (*e*) Sub-bituminous is applied to coals below the grade of bituminous, but above that of lignite. They are black and shining, but are light in weight and slack badly on exposure to the atmosphere. These coals are common in the western fields of Washington, eastern part of Montana, northern Wyoming, about Denver in Colorado, and in northwestern New Mexico. (*f*) Lignite is brown and woody, and occurs in North Dakota, South Dakota, Texas, southeastern Arkansas, Mississippi, and Alabama.

The classes noted above include all of the different kinds of coal that are known, but certain peculiarities of coals within the bituminous class have led to distinctions which are of great importance; thus the property of coking, which is limited entirely to the bituminous class, has given to coals possessing this peculiarity a value far above those coals having similar composition, but which do not possess this characteristic. The reason why one coal will coke and another will not is not understood; a practical test is the only way by which the coking properties of a coal are determined. Most of the coke is produced in the Appalachian coal field in Pennsylvania, West Virginia, Virginia, Tennessee, and Alabama.

The areas of the coal fields that lie within the various States differ greatly, even more than the production. The relative size of these areas is given above.

It will be a surprise to many to learn that the coal fields of Montana are more extensive than those of any other State, and that Texas is a close second. In this connection it must be understood that each of these States includes an enormous territory, equal to two or three of the smaller Eastern States. It is true, however, that most of the coal territory of these States is underlain by low-grade lignite, and hence the fields are not so important as their areas would indicate. The same is true of North Dakota, which includes an extremely large area of coal territory, but the fuel is wholly lignite and of comparatively little value.



COAL AREAS OF THE UNITED STATES.

Black shows anthracite and bituminous coal; shaded, lignite.

The extent of some of the coal fields is largely hypothetical. This is particularly the case with Washington, where the present estimate is probably far below the real extent of the fields. It might be supposed that Washington had been explored thoroughly enough to determine approximately the extent of its coal fields, but the peculiar conditions which prevail on the west slope of the Cascade range make it impossible to settle the question at the present time. The surface is deeply covered by glacial drift and vegetation, and it is only where the great streams, rushing down off the mountain slopes, have cut through this drift that the coal beds are exposed. In this way they are known at many localities, and it is probable that they are present in the intermediate covered areas, but no one is willing to say so until more prospecting has been done. When that occurs it is probable that the recognized area of the coal fields of Washington will be greatly increased. The known coal fields of Alaska seem to be comparatively small, having approximately the same area as the bituminous field of Alabama. Here again exploration may, and probably will, increase the area materially, especially that of the low-grade lignites of the Arctic slope.

The area given for the coal fields of Alabama includes only the bituminous coal of carboniferous age in the northeast part of the State. In addition to this, as shown by the accompanying map, there is a wide band of lignite-bearing tertiary rocks crossing the southern part of the State. These rocks are known to contain beds of lignite, but in the presence of high-grade bituminous coal the lignite has never been explored, and consequently the number of beds, their thickness and extent, are not known. It is possible that when the supply of better fuel is exhausted, or has fallen below the demand, the lignite field may be found to contain an important supply of fuel.

So far as our present knowledge goes, the distribution of the various classes of coal in the Western States is as follows:

Anthracite.—Only small areas of anthracite coal have been found in the Western States and Alaska. Generally these are the direct result of volcanic activity and hence are of limited geographical extent.

The largest field of anthracite coal in the Western States is in Gunnison County, Colorado, in the Crested Butte region. Apparently the anthracite in this field is the result of immense intrusions of igneous rock, which have baked the coal and thus driven off its volatile matter. The same coal beds only a short distance away are either bituminous or sub-bituminous in character. One other occurrence of anthracite is known in Colorado, in the Yampa coal field, in the northern part of Routt County. In this locality the coal has been changed to anthracite by dikes and sheets of igneous rock. This field is very limited in extent.

In New Mexico a small field of anthracite occurs near Cerrillos, on the Atchison, Topeka and Santa Fe. The field is small, and the anthracite is due to the baking effect of an intrusive sheet of igneous rock.

Utah claims a small field of anthracite coal in Iron County, near the southwestern corner of the State. It has not been developed and little is known of its extent or value.

In Washington a very small field of anthracite occurs in the vicinity of a large mass of igneous rock on Carbon River, southeast of Tacoma.

The largest anthracite field outside of Pennsylvania occurs near Controller Bay, Alaska. In this field the change in the character of the coal is said to be not directly related to volcanic activity, but to be due to the intense folding to which the rocks have been subjected.

At present, anthracite is mined in the West only in Gunnison County, Colorado, and near Cerrillos, New Mexico.

Coking Coal.—Good coking coal is scarce in the western fields. The principal source of supply is the Raton, or Trinidad, field, in southern Colorado and northern New Mexico. Of the coke produced in the western fields, 70 per cent comes from this region. Some coke is also produced in Colorado, on the west side of the Front range, at Durango and in the vicinity of Glenwood Springs. Other important centers of coke production are Castle Gate and Sunnyside, in Utah, and along Carbon River southeast of Tacoma, Wash. Coke is also made to a limited extent in Wyoming near the Black Hills and in southern central Montana. There are several other fields that will coke with difficulty, which may be developed in the future, but the present prospect is not particularly promising.

Bituminous, Steam and Domestic Coal.—This class of fuel is much more abundant than either of the two preceding classes. In New Mexico the largest deposit of such coal is in the Raton field, in the north central part of the territory. Similar coal also occurs in the northern part of the great Durango-Gallup field, in the northwest corner of the territory, and in several small fields south of Santa Fé.

In Colorado good bituminous coal occurs in the fields just mentioned, at Trinidad and about Durango. It is also present in the small field south of Canyon City and in Gunnison County. As shown on the map, the latter field occupies the southeastern point of a large synclinal basin which extends as far west as Castle Gate, Utah. The coal outcrops on the south limb of this basin in the Book Cliffs west of Grand Junction and along the "Great Hogback" from Gunnison County northwestward through Glenwood Springs and Meeker. Throughout the whole line of outcrop around this basin the coals are of the bituminous class, although in places they belong to the lowest group of the class. Good bituminous coal also abounds in the Yampa field, in Routt County. Thus it will be seen that Colorado has a large supply of this class of coal.

Utah is also well supplied by the same basin and by its extension southward from Castle Point along the Wasatch plateau. There is also a small field at Coalville, east of Salt Lake City, and a field of unknown extent in Iron County, occupying the Colob plateau.

Wyoming has bituminous coals along the line of the Union Pacific at or near Hanna, Rawlins, Rock Springs, and Kemmerer, and also in small areas about the Black Hills. It is possible that other areas of bituminous coal exist in this State.

Montana has considerable bituminous coal in the fields along the Northern Pacific west of Billings, about Great Falls and in the Crazy Mountains, but by far the largest areas in the State carry coal of an inferior grade.

Washington has several bituminous coal fields along the western foothills of the Cascade Mountains and at least one local basin at Roslyn, on the eastern side.

Most of the coals of California are of low grade, but one bed has been developed in Stone Cañon, in the southeast corner of Monterey County, that is good bituminous coal. So far as known, this is the only coal of this class in the State.

Sub-bituminous Coal.—This class of coal is abundant in the western fields. Most of the coal in the south part of the Durango-Gallup basin is of this class. It is the only coal found in the Denver basin and in North or South Park of Colorado. The great fields in the northeastern part of Wyoming, the Big Horn basin, and most of the fields in Uinta County contain sub-bituminous coal. All of eastern Montana is supposed to be underlain by it, as is also the big field in the north central part of the State around the Bearpaw Mountains. A number of small fields lying west of Butte, Helena, and the main front range contain coal of this character, but generally they are of small extent and probably have little commercial value. In Washington this class of coal is abundant, but as a rule it occurs some distance west of the Cascade Mountains.

Lignite.—This class of fuel is found only in the fields of southern Alabama, Mississippi, Arkansas and Texas on the Gulf slope, and North and South Dakota at the north. It is mined commercially only in North Dakota and Texas.

Up to the present time we have used our fuel without question as to possibility of its exhaustion. Of late, however, more far-seeing people have been thinking deeply on this subject, especially since the recent order of the President withdrawing temporarily from coal entry 64,000,000 acres of coal land, and his recommendation to Congress that the time has arrived to begin the conservation of our mineral fuels, and urging upon that body the passage of laws upon the subject.

In the older fields of the East, with the exception of Indian Territory, practically all of the coal land has passed to private ownership. Therefore the President's order and the interest of the people generally centers about the coal fields of the Rocky Mountain region and the Pacific slope. The former contains an area estimated at 134,800 square miles, and the latter, including Alaska, 10,000 square miles, or a total of 144,800 square miles out of a total for the whole country of 400,500 square miles.

Of this area of 144,800 square miles of coal fields of the Western States, it is estimated that 50 per cent has passed to private ownership, leaving about 72,000 square miles of coal fields yet belonging to the government. It must be remembered, however, that more than half of this area is included in the lignite fields of eastern Montana, North Dakota, and South Dakota, and when this is deducted from the figures given above, it leaves an area of only about 33,000 square miles of fairly good coal, the title to which is still vested in the United States.

The estimated amount of coal in the coal fields of the United States, not including Alaska, is 2,200-000,000,000 short tons, enough, if it were molded into a block, to form a cube with a side 7½ miles long, or spread out flat to make a layer 6½ feet thick over the 400,000 square miles of coal fields of the United States. Is not this amount, to all intents and purposes, inexhaustible? In order to judge about this, it is necessary to know the rate of consumption.

The total production of the United States in 1906 was over 414,000,000 short tons. The United States leads the world in coal production by over 100,000,000 tons, Great Britain, and next Germany, being the only countries which produce more than about 50,000,000 tons a year. If the present rate of coal consumption should be maintained from now on, the coal of the United States would last nearly 4,000 years. On the other hand, the increasing rate of coal consumption in the United States is an alarming factor in considering the future supply. The rate of increase is enormous, the amount produced in each decade since 1816 being equal to the entire previous consumption. The amount of coal consumed in the ten years from 1816 to 1825 was about 315,356 short tons. In the ten years from 1896 to 1905 the consumption was over 2,832,599,452 short tons. If the consumption of coal continues to increase in the future as fast as it has during the last ninety years, the coal supplies of the United States will be exhausted in about one hundred years. Since there is every prospect of a constantly increasing demand for coal, it seems probable that the rate of consumption will increase at nearly the same ratio as in the past, and hence that the life of the coal fields of the United States will be about two hundred years.

A NEW STUDY OF THE BRAIN.

WHILE the liver and later the heart were taken by the ancients as the most important part of our human anatomy, we now have for centuries accorded this place to the brain. The literature on the brain is very large. To it is to be added a recent essay by Prof. Edward Anthony Spitzka, of Philadelphia, who read an interesting paper on the Study of the Brains of Six Eminent Scientists and Scholars before the American Philosophical Society, on March 16, 1906, which essay has now appeared in separate form.*

Besides the main part, the essay contains very good statistical material, which the author has collected with great industry. Thus, he gives a review of the weight of the brains of 130 notable men and four women. Among these there are twenty-seven Americans, including Canadians, thirty-eight Germans and Austrians, twenty Frenchmen, fourteen British, three Swedes, two Russians, and one each belonging to Italy, Spain, Bulgaria, and Japan. The average weight of these brains was for the Americans 1,519 grammes, British 1,481, Frenchmen 1,456, and Germans and Austrians 1,439. Of 108 notable individuals the average weight was 1,473 grammes. It is interesting to learn that Napoleon III, who died at the age of sixty-five years, had a brain weighing 1,500 grammes, and the insane King of Bavaria, who drowned himself at the age of forty-one, one of 1,349. The weight of the brains of Oliver Cromwell (2,233 grammes) and Lord Bryon (2,238, or 1,924, or 1,807 grammes) is based upon doubtful statements.

The author gives a list which is led by the Russian novelist Turgenjew (sixty-five years of age), with 2,012 grammes. We find Cuvier with 1,830; Dr. Abercrombie, 1,786; Thackeray, 1,658; the physicist Siemens, 1,600; Dr. Simpson, 1,531; Daniel Webster, 1,518; Agassiz, 1,495; Lord Jeffrey, the jurist, 1,471; the Russian general Skobeleff, 1,457; Bertillon, 1,398; Bischoff, 1,370; Liebig, 1,352; the explorer Schlagintweit, 1,352; Pettenkofer, 1,320; Tiedemann, 1,254, and Gall, 1,198. The noted chess player, Steinitz, who died insane, had a brain weighing 1,462 grammes, and the composer Schumann, who also died insane, one weighing 1,352. Gambetta's brain is said to have weighed 1,160 grammes, but it was not weighed fresh.

Our author describes the investigation made to estimate brain weight approximately from the cranial capacity. "The difficulties that are encountered in this procedure are obvious, for the factors of age, cranial form, state of nutrition, and the condition of disease prior to death influence the calculation greatly." But we all know that it is not the weight of the brain which is of import. Von Bischoff (Das Hirngewicht des Menschen, Bonn, 1880), to whom our author very often refers, says that even Galen (De usu partium, viii, ch. 13) attached more importance to the quality than the quantity of the brain. This Munich professor of anatomy has collected 906 fresh brains, 559 of men and 347 of women; he found the average male brain to weigh 1,362 grammes, with a bodily weight of 49,522 grammes, and the female brain 1,219 grammes, with 42,701 of bodily weight. This work, although thirty years old, is still the standard work on the subject. The first scientific weighing of the brain was undertaken, by the way, by Dr. Sims, who reported his results, under the title of On Hypertrophy and Atrophy of the Brain, in the Transactions of the Medical and Chirurgical Society of London, 1835, where he gives a table of 253 brains, stating the sex, age, the cause of death, and the condition of brain. Tiedemann's work followed in 1836 in English, 1837 in German: Das Gehirn des Negers verglichen mit dem des Europäers und des Orang Utang.

Dr. Spitzka also speaks of the regions of the brain. He gives it as his opinion that the insula is of great

* "A Study of the Brains of Six Eminent Scientists and Scholars belonging to the American Anthropometric Society, together with a Description of the Skull of Prof. E. D. Cope." Extracted from Transactions of the American Philosophical Society, N. S., vol. xxi., part III. By Edward Anthony Spitzka, M.D., Professor of General Anatomy, Jefferson Medical College, Philadelphia. Philadelphia: The American Philosophical Society, 1907. Pp. 175 to 308.

importance, particularly to speech. "This," he says, is the purest association center in the brain and its surface configuration is somewhat of an order of the degree of development of the general cerebral surface." The insular cortex is, furthermore, the thickest in the cerebral mantle, and the fusiform cells in the deepest layer are very abundant. The author observes that, as a rule, in the brains of intellectual persons the left insula is the larger, and the præinsula, which is in close juxtaposition with the cerebral centers for articulate speech, is most redundant.

The author states rightly that many more brains will have to be obtained and examined, especially brains of leading men, before we can come to important conclusions. To obtain such brains there have been founded a society in France and two in the United States, the American Anthropometric Society and the Cornell Brain Association.

Dr. Spitzka cites the will of the German anatomist, Tiedemann, in which this Heidelberg professor wrote: "Den Körper lasst öffnen es gewährt dies vielleicht einigen Nutzen, findet sich ein Theil, der den Aertzen Belehrung gewähren kann, so nehme man ihn in eine anatomische Sammlung auf."

PRESERVATION OF BOOKS IN HOT CLIMATES.

SUGGESTIONS FOR THE TROPICS.

BY FRANK BROWNE, GOVERNMENT ANALYST, HONGKONG.

IT is well known that books in hot climates quickly deteriorate unless carefully looked after. There are five destructive agencies which have to be guarded against: (1) damp, (2) a small black insect (anobium), (3) cockroaches, (4) the silver fish (Lepisma), and (5) the white ant.

(1) Books which are kept in a damp atmosphere deteriorate on account of molds and fungi, which grow rapidly when the conditions are favorable. When there has been a prolonged spell of moist weather their covers should be wiped, and they should be placed in the sun or before a fire for a few hours. Damp also causes the bindings and leaves of some books to separate.

(2) The anobium, or bookworm, is a small black beetle, ⅛ inch long and 1/16 inch broad; it is very destructive, and books will be found, if left untouched, after a few months to have numerous holes in the covers and leaves sufficiently large for the animal to pass through. If this insect be allowed plenty of time for its ravages it will make so many holes that bindings, originally strong, can be easily torn in pieces. A book containing them should be at once separated from others, otherwise all are likely to become similarly affected. Sound books kept in a closed bookcase in which naphthalene balls are placed do not become damaged, and a damaged book does not get worse, a naphthalene atmosphere being apparently fatal to these insects. When these are killed in the manner recommended by Dr. T. E. Thorpe, C.B., F.R.S., and as described below, it is well to do it in the coldest part of the year, as on the approach of hot weather these insects are frequently found roaming from their borings. Recently the authority above quoted has drawn attention to the usefulness for insects of a paint, recommended in 1888 by the British consul at Swatow. It is composed of 5 drachms of corrosive sublimate and 60 drops of wood creosote in a quart of rectified spirit. This preparation can be used with advantage against all insects. Cockroaches prefer starvation to eating covers protected with it.

(3) The appearance of a fine binding may be destroyed in a single night by cockroaches. The lettering of the binding may, in two or three days, be completely obliterated. A good protective is the paint mentioned in (2), or the books may be coated with a hard—the harder the better—varnish. In Hongkong a cheap kind made by Chinese, and sold at about 9d. a pint is as good as any. From information obtained at the factory it is said to consist of:

Shellac	30 parts
Common resin	40 parts
Gum thus	60 parts
Spirit of wine	320 parts

The resins are finely powdered, and pine leaves and other impurities are removed from the thus by sifting, after which they are macerated in the spirit for several weeks. An analysis of this quickly drying varnish gave 28 per cent of resinous matter—a result quite consistent with the stated composition. This varnish does not keep out the anobium insect, and the addition of corrosive sublimate to it does no good, as the mercury salt is reduced to calomel. Some persons use the paint on the book first, and afterward varnish.

(4) The silver fish, though preferring paper, will attack wood or cloth. It does not bore, but grazes the surfaces of paper. Naphthalene keeps it away.

(5) White ants are usually detected by their traces before they get into bookcases. The practice of raising all movable furniture 2 or 3 inches from the floor, so as to give an air space, is most useful, and is indispensable in hot climates. With books protected by naphthalene vapor these insects need not be feared. A solution of asphaltum in coal tar naphtha (1 in 5) painted on the well-seasoned wood has been found a good protective, so it is mentioned should there be any desire to coat the interior of book receptacles with some such material. Probably a coating of well-boiled tar would prove as useful, but either coating is unnecessary except in very special circumstances.

General Suggestions.—Where it is necessary to keep books or paper of any description in boxes, cupboards, or closed bookcases some naphthalene balls should be always present with them, and there will be no damage from insects and very little from damp. In dry weather the doors of closed bookcases should be left open occasionally, as a damp still atmosphere is most favorable for deterioration. In damp climates pictures would be greatly protected by arranging a receptacle on the back, so as to expose the print to the vapor of naphthalene. As in hot climates naphthalene balls of ordinary size volatilize somewhat quickly—usually under a year—it has been found best, to save trouble, to use large blocks instead. A piece 4 inches square will last at least five years, but a stock of pieces 2 inches square together with some balls of ordinary size would probably be more convenient for general purposes.

Dr. T. E. Thorpe, C.B., F.R.S., has pointed out that, for the treatment of books and papers already infested with insects the evidence available is in favor of carbon disulphide. He recommends that the various articles be lightly disposed in a chamber made as airtight as possible, and exposed for, say, twenty-four hours, to the insecticide placed in saucers. For a chamber 5 by 3 by 3 feet, a breakfast saucer half filled with the liquid may be used. His instructions include a warning that care must be taken to insure the complete absence of disulphide vapor before a light be brought near the room or receptable.—The Pharmaceutical Journal.

THE PRESERVATION OF EGGS.

FEW people not directly connected with the trade have any adequate idea of the extent to which the egg of the domestic fowl is imported into England. Whether the volume of this trade ought to be an unmixed source of satisfaction to us is another question, for there can be little doubt that if some of the energy, enterprise, and organizing power which have been turned to such excellent account in Denmark, for example, were applied to the production of eggs in this country, we should be less dependent than we are on foreign supplies. Intimately bound up with this question of egg production is that of their preservation; but although much has been written on the value of particular methods, no systematic investigation of the conditions under which eggs must be kept to maintain and insure their quality as food has hitherto been attempted, nor has any proper comparison been made as to the relative merits of the various methods which are practised. Those who are interested in this important subject will therefore welcome the appearance of a paper by Mr. Fr. Prall in a recent number of the Zeitschrift für Untersuchung der Nahrungs- und Genussmittel (No. 7, vol. xiv., October 1, 1907, p. 445), in which the question is treated both observationally and experimentally with all the precision and care which should characterize a scientific inquiry.

The adequate solution of this problem demands that the eggs when preserved shall maintain their normal appearance, smell and taste; in other words, they must in nowise differ in chemical and physical characters, or in behavior on cooking, from fresh eggs. The chemical and physical changes to which eggs are naturally subject are largely dependent on the temperature and relative humidity of the air, and on the presence in it of molds and germs. In an absolutely sterile atmosphere at a sufficiently low temperature and of a proper degree of humidity, eggs will preserve their "freshness" for very long periods of time, if not indefinitely; and all successful methods of keeping eggs imply a practical recognition of these conditions.

Of the various methods of distinguishing old and bad eggs from fresh eggs, one of the simplest is to make a hole of about the size and shape of an egg in a wooden or tin box, and hold the egg in the hole of the box against the light behind the hole. Good sound eggs are thus seen to be perfectly transparent without striations or spots, and the bubble of air within is not wider in diameter than a ten-cent piece.

Eggs selected for preserving should be those of well-fed fowls—preferably from those of which corn is the chief diet. The eggs should be quite clean; if dirty they should be washed with a little dilute alcohol (50 per cent), and carefully dried.

In what may be called "dry conservation," the main thing is to keep the surrounding air as clean as possible, and free from smell. The temperature should be low, but should not sink much below 32 deg. F., otherwise freezing might cause the eggs to burst. The relative humidity should be from 60 to 80. The best plan is to stand the eggs on an egg-rack, with their points downward, in a cool, light cellar, and preferably in an ice closet, or, on the large scale, in cold-air stores, so that the air can circulate freely around them. Nothing is gained by turning the eggs at short intervals, say weekly, as recommended by some; or by packing them in salt, sawdust, powdered coal or charcoal, wood ashes, sand, etc. Some of these things are found to "taint" the eggs; others are apt to become damp and set up the action of molds.

It is occasionally recommended that the egg should be protected from the outer air by covering the shells with fat, vaseline, paraffin wax, collodion, etc., or that the shell should be treated with salicylic, boracic, or hydrofluosilicic acid, or even sulphuric acid, whereby the calcareous material is chemically altered and made less pervious. Immersing the egg in Condy's fluid or a solution of potassium permanganate has also been suggested. Eggs so treated in no case were found to keep better than by cold storage in pure air.

Eggs which cannot be kept in cold stores or in an ice chest may be preserved by Hanika's method. This consists in first putting the clean eggs into recently boiled water at a temperature of about 110 deg., and then dipping them into boiling water for ten seconds, after which they are to be immediately put into cold water. By this treatment all organisms are killed, and a hard coating is formed between the shell and the "white." The shells are finally washed with a little strong alcohol, dried, and placed in clean, dry saw-dust. Eggs so treated were found to be in perfect condition after the lapse of nine months.

Attempts are frequently made to preserve eggs by immersing them in solutions of various salts, or of substances which are known to act as antiseptics. Few of these solutions give a wholly satisfactory result; indeed, many of them, as, for example, salt, salicylic acid, borax, and glycerin, penetrate the shell, and either harden the yolk or impair the flavor. Of these liquids lime water has been most frequently used, but by long immersion in this solution the yolk is apt to mix with the white, and the shell is rendered so fragile that it is very liable to be broken on boiling. The white of an egg which has been kept in lime water is difficult to "whip." Much better results are obtained by the use of a 10 per cent solution of water-glass, especially if the shells are smeared with fat or vaseline, whereby the slight taste of the alkali which the eggs are otherwise apt to acquire may be obviated.

Mr. Prall's paper, which contains the results of many hundreds of experiments and carefully made observations, arranged in tabular form and set out in detail, is a valuable contribution to the economics of an important food problem and merits careful study by those who are interested in the subject.—From Nature.

A Remedy for the Ice-Box Odor.—The sole means of eliminating the characteristic ice-box odor is washing out with soap and water, to which some chloride of lime has been added, says Werkstatt. After thorough drying and airing, the white deposit that appears on the zinc lining must be rubbed off with emery paper. This is a tiresome job, and if frequently repeated, soon wears out the sheet metal covering. But as a thorough cleansing, for a single occasion, the process is attended with satisfactory results.

SCIENCE NOTES.

At Paris a decree promulgated last year determined the exact method of taking samples of milk in order to make the analysis at the municipal laboratory. From each specimen is taken a quarter of a liter in bottles of white glass which are clean, dry and odorless. Before they are corked, into each bottle is introduced a special compressed tablet of bichromate of potash. But the use of the bichromate as a preservative for the milk is objected to by some competent authorities on the ground that it has some serious drawbacks. One of these is that we must take account of the quantity of bichromate in order to correct the weight of the ash in the analysis. Another is that it becomes impossible for the expert to say whether or not the milk had previously had bichromate added to it by fraud. This was found to have occurred in several cases. Again, if we have to deal with milk which has already commenced fermenting, as often happens in summer, we can no longer estimate the acidity of the milk so as to make the correction for the weight of the lactose. A part of the bichromate is in fact reduced, and this is easy to notice when it is observed that the hue of the milk, a deep yellow at first, now becomes a light yellow and then a green-yellow. We are also deprived of the good indications which are furnished by cryoscopy and refractometry as concerning fraudulent watering of milk. But the greatest disadvantage is that adding bichromate to milk, even in 2 per cent proportion, and without addition of sulphuric acid, causes the formation of a body having an aldehyde function, that is it gives the general reactions of aldehydes. When the expert is not forewarned, he will always find formol in the suspected milk, when in fact it was quite free from it, and so would give an improper judgment upon it.

A new process for the extraction of casein by electrolysis has been devised by a Parisian inventor, M. Gateau. The skimmed milk is heated to about 80 deg. Centigrade and deposited in a large tank. Within this is immersed a porous pot charged with a five per cent solution of caustic soda and in which is dipped an iron cathode, the anode, composed of carbon, being placed in the milk itself about 4 inches distant from the other electrode. By the passing of an electric current adjusted to 0.01 ampere per square centimeter of the surface of the anode plate, phosphoric acid is set free in the milk, causing the casein to precipitate. All the casein contained in 26.5 gallons of milk can be secured in this manner within the space of about twenty minutes with a current of 160 amperes at 11 volts. Though this is the principal process of electrolytic production devised by the inventor, the casein can be secured by alternative methods which are variations of the same idea. By charging the porous pot with whey obtained in a previous electrolytic process, and maintained at the same degree of concentration resulting from precipitation of the casein, with the same disposition of similar electrodes, all the casein in 26.5 gallons of milk can be obtained within ten minutes with a current of 160 amperes at 18 volts. The advantage of this latter method is the precipitation of the product in a much shorter time. Skimmed milk so treated gives a higher percentage of casein, while at the same time as no foreign deleterious products are introduced into the milk, the resultant product is considerably purer.

In the Annalen der Physik H. Greinacher describes some work on the radio-activity of matter in general. The known radio-active elements are very few, and the question arises whether radio-active properties are not possessed by all kinds of matter. The case may be analogous to that of magnetism, which at first appeared to be a property of some elements of the iron group only, but afterward was found to be common to many other bodies, though in a slighter degree. The author investigated various substances with a view to finding whether there was any indication of the radiation of particles. The method adopted was a thermal one, and tests were made to determine whether the substances examined showed any trace of being at a higher temperature than their surroundings. The materials examined were placed in Dewar vessels surrounded by ice and kept there for many hours, their temperature being measured by means of a thermoelectric arrangement. The substances investigated were $ZnSO_4$, $CdSO_4$, $MgSO_4$, Zn, Cd, $UO_2(NO_3)_2$, Hg and Bl and $Pb(NO_3)_2$, and it was found that the temperature differences which these (with the exception of lead nitrate) showed above their surroundings amounted to at least less than 0.01 deg. Crystalline lead nitrate was an unexplained exception, as it showed a temperature of one or more hundredths of a degree less than that of its surroundings. It was calculated that the heat which the investigated substances could have produced by a radio-active transformation amounted at most to some millionths of that of radium, for Hg especially 1/1000000 was found as upper limit. It was thus indicated that the method of Dewar vessels permitted of an accurate determination of the heat development of radio-active substances. The temperature fall (radial) in an endless cylinder was calculated if its surface was kept at constant temperature. The magnitude of this temperature gradient was also deduced from a more general formula obtained by the author, and the result is that the values calculated in this way are considerably smaller than those found experimentally by Thwing.

ENGINEERING NOTES.

The Boletin Official of Argentina, of November 8, contains a copy of a decree authorizing the Inspeccion General de Puentes y Caminos to construct an iron bridge over the Arroyo del Medio, on the road from Pergamino to Rosario, at a cost of 85,000 pesos currency—about $37,000.

According to the Engineering Record the surprise signal tests made during October on the Pennsylvania Railroad were the most satisfactory ever made. There were 2,245 of these tests, and of them 98.8 per cent were absolutely successful, and the remaining 1.2 per cent were marked deficient merely because the signals were passed only a few feet. Taken as a whole, the October record was 1.2 per cent better than that of September, the best previous month. Fifteen entire divisions received a perfect rating, while only ten divisions were so rated during September. Five divisions were above 97 per cent, and only one fell below 90 per cent. The skill attained by the trainmen in observing signals is shown by the fact that there was but one failure in the 952 tests on the very busy lines of the Schuylkill division.

According to Defforges, gravitation is too strong above the seas and too weak above the continents, states G. Costanzi in Comptes Rendus. Many observations are not in agreement with this rule, however, notably those of Nansen on the Arctic Sea and ice, of Riccò in Calabria and Hungary, of Hecker on the Atlantic and Pacific, of Gurgo and the author in Central Europe and Japan. According to the author, the absolute maxima of the negative anomalies are not along the main axis of a mountain chain, but along a line parallel to it and opposite the greatest neighboring depression; the maxima of the positive anomalies are not above the depressions, but are displaced toward those anomalies; the direction of the displacement is approximately that of the normal on the external side of the curved mountain chains. The only exception to the first of these three rules is Etna, on which the maximum negative anomaly occurs at the summit. The observed irregularities suggest that there is general movement of the ground and a movement of the lower strata of the earth relative to the upper; the upper strata lag behind the lower. The displacement is to the north in the case of the Alps, Eastern Carpathians, and Northern Apennines, in accordance with the views of Suess and of Bertrand.

The results of investigations of aluminium copper alloys by H. C. H. Carpenter and C. A. Edwards are published in several English papers. The equilibrium curves so far as they have been studied by the authors confirm generally Guillet's results. It was found, however, that the liquidus in the neighborhood of 44.5 to 50 per cent Al does not rise, but is nearly a horizontal straight line. From 0 to 13 per cent Al the solidification is in each case completed at the temperature at which it commences. Evolutions of heat occur in the 8 to 13 per cent Al alloys at temperatures between 500 deg. and 600 deg. C. For small castings there is no need to re-melt in order to get sound metal; the lowest pouring temperature consistent with fluidity is the best. The total linear contraction of castings cooling from the solidification point to ordinary temperature was from 1.83 to 2.34 per cent for the copper-rich alloys, and uniformly 1.66 per cent for alloys from 0 to 3.76 per cent Cu. A chill casting and a rolled bar of the same composition have the same sp. gr. The sp. gr. of Cu is reduced according to a smooth curve upon addition of Al up to 13 per cent. The results of mechanical tests show that the limits for practically useful alloys are 0 to 11 per cent Al and 0 to 4 per cent Cu. From 0 to over 7 per cent Al, the alloys have low yield-points, moderate tensile strength, high elongation, almost uniform hardness (Brinell), extremely high deformation before rupture in torsion, and good resistance in dynamic tests. This series is not very sensitive to heat treatments, and is much improved by mechanical work. From 8 to 11 per cent Al the yield-point is low, maximum stress good, ductility good (up to 10 per cent), hardness rapidly increases, resistance to torsion and impact falls. A parallel in many respects can be drawn between the properties of an alloy with 9.9 per cent Al (the well-known "aluminium-bronze" or "aluminium-gold"), and a carbon steel of about 0.35 per cent C. It is shown that the yield-point of the copper-rich alloys is the same as that corresponding to the limiting stress to produce failure under a million reversals; this is different from the case of steel, whose yield-point as observed in static tests is higher than the real value, probably through the mechanical treatment which it undergoes. In order best to develop the properties of the Al-rich alloys, it is essential to submit them to considerable mechanical working. With 3.76 per cent Cu the following figures were obtained: sp. gr. yield-point, 18.5 tons per square inch; ultimate 20 tons per square inch. The Cu-rich alloys are tically incorrodible by sea-water, whether alone contact with steel. They are in this respect sup to Muntz metal and naval brass. In tap-water positions are reversed. The Al-rich alloys are r corroded by sea-water but not by tap-water.

TRADE NOTES AND FORMULÆ.

Vinegar Factories.—Protection for the walls in gar factories. Gutta percha varnish: 2 parts of rosin is melted, and to this 1 part of well-dried percha added. When both are equally melted, with oil of turpentine, if desired add some zinc w rubbed down in linseed oil varnish, or better, finely precipitated heavy spar or dried baryta (*blanc fixe*).—Bersch.

New Fuel for Motor Vehicles.—A mixture of a and acetylene, and the production, in this manner a rapidly burning vapor for the operation of especially automobiles, is proposed (according to German Fahrzeugzeitung) by Barker and White. have secured protection for a process, according which the denatured alcohol is vaporized in an nary benzine vaporizer and the vapor conducted dry calcium carbide. As the alcohol, and also vapor, always contains moisture, by this means acetylene is produced and mixed with the al vapor. This mixture is said to furnish a more and better ignition and also a very high calorific because, as a result of the process, the alcohol is prived of water. According as the alcohol used is more aqueous or of higher percentage, the volum acetylene developed is larger or smaller.

To Bleach and Finish Straw Hats.—For bleach straw hats the Pharmazeutische Zeitung (Berlin) the following recipe: Peroxyhydrate of barium, bisulphate of sodium (pulverized), 17; borax (pul ized), 8.8. By the action of the bisulphate of so on the peroxyhydrate of barium, peroxide of hy gen is generated. The borax serves to affect the ishing, making the straw fibers more accessible to bleaching medium. For straw hat finishing, the lowing recipe is given: Shellac, 110; borax, 60; w 800; glycerine, 50; coumarin, 0.5. After the borax been dissolved in water, add the shellac of good q ity in small portions, stirring vigorously. Avoid h ing too much, about 167 deg. F. is best. When the lac is almost dissolved, add the glycerine and marin, strain and make up to 1,000. It should b plied with a camel hair brush. In order to pre the hardening of straw hats, which often occurs a washing and bleaching, they should be dipped, a cleaning, in very dilute glycerine water 1 to 100, dried on a suitable block.

An Innovation in Metal Working.—A new, q working tinning solution, for brass and copper, is scribed in the Zeitschrift für angewandte Chemie, cording to a communication in Bayrisches Indus und Gewerbeblatt. The usual method of tinning br and copper with a solution of cream of tartar metallic tin is in various respects open to objection; requires from 6 to 12 hours, the cream of tartar is pensive, the deposit of tin is not bright and requi further treatment; the bath also requires some t before it is saturated with tin.

The formula for the new method is: Water, parts; caustic potash, 34 parts; chloride of tin, parts. Preferably a cast-iron kettle, steam jacke or failing this an ordinary tank equipped with steam coil is used. The water and caustic potash first heated until the latter is dissolved, after wh the tin salt is added. When the solution has the ri composition and temperature, a deposit will at begin to form on the objects immersed in it, which one minute begins to develop into a thin coating in five minutes answers almost every purpose. the tinning of brass objects, the average period treatment may be given as five to ten minutes; copper articles a somewhat longer time is requir The temperature of the bath may be kept at 150 to 200 deg. Fahr.

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